Erin Welsh	Hi, I'm Erin Welsh and this is This Podcast Will Kill You and you're listening to the latest episode in our miniseries of bonus content that we've been releasing over the past couple of months. We're nearing the end of these bonus episodes for now, we've got just one more planned after this but that doesn't mean that we won't come back with more someday. In fact we'd love to do that because these episodes have been so much fun and they are such a great way to explore even more deeply a topic we covered in our regular season episode. For instance, we've been able to dig deeper into the world of the Epstein-Barr virus after our multiple sclerosis episode, learn about how koalas are impacted by chlamydia, understand more about the stigma and discrimination experienced by some people living with hepatitis B, and so much else.
	In this week's episode we're deviating a bit more from our regular episode topic than we usually do but I think that makes it all the more exciting because this bonus episode covers something that Erin and I have frequently mentioned and expressed our love for on the podcast but have never taken the time to explore in more depth. And that is coprolites, aka fossilized feces. In our episode last week we talked tapeworms, mostly about the tapeworms that commonly infect humans. But those tapeworms only represent a teeny tiny part of the puzzle of these parasites. As we mentioned, tapeworms are an incredibly ancient and highly diverse group of parasites infecting thousands of animal species all over the globe. We're learning more about these amazing creatures all the time from the discovery of new species, expanding what we know about present day tapeworm ecology to the identification of tape room bits in fossils, filling in some of the gaps in our knowledge of how these parasites and their hosts have evolved. And it's the second part, the fossil part, that I really want to focus on for this bonus episode.
	If you listened to our tapeworm episode last week you may remember me mentioning a study from 2013 that found tapeworm eggs in fossilized shark feces from 270 million years ago, which is so incredible not only for the simple fact that we can look at and examine poo from millions of years ago but also because this finding completely revised what we know about the timeline of cestode evolution and the history of intestinal parasites. And that's typically how coprolites come up on the podcast, when we trace back how far a human-parasite relationship extends or examine how historical distributions of parasites differ from those of today. But coprolites are much, much more than a tool for understanding parasite evolution or host-parasite relationships.
	These magic packages, as my guest for this episode has called them, can yield incredible amounts of information on the typical diet of an extinct animal, the ecological relationships among species, and the environmental conditions near the time of fossilization, among other things. Although people have been studying coprolites since the first decades of the 1800s, some of the most impactful discoveries in this field have been made in just the past few decades by Dr. Karen Chin, who is one of the world's leading experts in coprolites. Dr. Chin has so graciously agreed to let me ask her all kinds of questions about fossilized feces today and I am incredibly excited to dive in. So let's just take a quick break here and get to it.
TPWKY	(transition theme)
Karen Chin	My name is Karen Chin and I am a professor at the University of Colorado Boulder and I'm also Curator of Paleontology at the CU or University of Colorado's Museum of Natural History. I study ancient ecosystems and mostly I focus on Mesozoic ecosystems which is the time when the big dinosaurs were roaming around.

Erin Welsh	Awesome. Thank you so very much for joining me today. I have been absolutely fascinated by coprolites ever since learning about them during my master's and reading about hookworm eggs and the peopling of the Americas and all the things we can learn from fossilized poop. And I've always wanted to dig in a little bit deeper and explore more especially of the non parasite side of things. So I am really thrilled for this interview.
Karen Chin	Well thank you, thank you for inviting me.
Erin Welsh	Of course. So could you start us off by defining the word coprolite?
Karen Chin	Yes I can. A coprolite is fossilized feces. Sometimes people immediately think it has to be from a dinosaur but it could be from a fish or a human or an insect. It just means fossilized feces. And there's a whole variety of them. But I would say that since I work on very old fossils, most of the fossils I work on are over 66 million years old but coprolites can be preserved in very - what I would call - young sediments only a few 100 years or a few 1000 or a million years old. And how they are preserved often depends on their age. So what the kind of coprolites I work on are hard, they're mineralized, whereas if you talk to an archaeologist, many of the coprolites they work on were preserved through drying, through desiccation. And if archaeologists rehydrate them, they can still have odors where most of the material week work on is mineralized.
Erin Welsh	What do coprolites look like? I'm sure there's not a one size fits all answer to this question. And so how variable can they be in their shape and size?
Karen Chin	That's a great question. They're highly variable and their variableness often depends on how big they are. So if you're talking about little feces from insects or shrimp, they often have a very predictable size and shape. But if you're talking about feces from say a duck-billed dinosaur, often they just do not hold their shape either when they're deposited or when they're trampled. And you can see that yourself if you go to the zoo and look at the elephant dung, one or two of them might have a nice round shape but many of them are just kind of trampled and have no recognizable shape. So the shape is usually dependent on the size of the animal. And then within that, when feces are first produced they can be little teeny pellets, they can be ovoid, they can be more like a cow pie, they can be really irregular and this depends again upon the size and also upon the diet and the kind of animal that produced it.
Erin Welsh	Coprolites are a type of trace fossil, right? So what are some other examples of trace fossils and how does the information that we can get from these type of fossils differ from the info we can glean from something like a body fossil for instance?
Karen Chin	Yes, that's a great distinction. Body fossils are part of what the animal looked like or a plant, I shouldn't limit it to two animals. Petrified wood is a kind of body fossil because that's part of what constituted the structure of the animal. In contrast, trace fossils record behavior of different organisms. So tooth marks in say bone or burrows in the sediment or footprints or coprolites, they all record some kind of behavior. And they tell us, they provide different perspectives because with body fossils we can try to envision what an animal or plant or whatever looked like, some kind of organism what they looked like. But with trace fossils we can see they burrowed here, they burrowed in this manner, what were they doing, what did they eat, how did they walk, how fast did they run. They're different kinds of questions but they enrich our understanding of ancient life.

Erin Welsh	Of course everyone and everything poops generally speaking. But what's in that poop can change substantially from day to day. And so if a trace fossil like a coprolite is capturing a snapshot of an image, a snapshot of what that animal ate and that particular day what and what happened to just be preserved. And so how does that affect our interpretation of what we see inside that coprolite?
Karen Chin	Well I like that you use the the phrase snapshot, we like to use that to because it's just kind of a single frame in the whole movie of ancient life and sometimes it can be representative of the past and sometimes maybe it was an aberrant situation. Maybe it would be like if you looked at my diet on a day that all I wanted to do was eat ice cream, that might not be relevant for my normal diet.
Erin Welsh	So you mentioned of course that the size of the animal and the type of the animal can really affect what the coprolite looks like simply because of what's in the poop and and so on. But how does that affect how coprolites form? Well I guess my first question is how do they form? And then the second sort of add on question is how do things like animal diet or the environmental conditions, how do those things play a role in whether or not that poop becomes fossilized?
Karen Chin	Yes, all those factors are super important. If we go back to thinking about archaeological samples that are only maybe hundreds or thousands of years old, those can preserve in a very dry environment, say in a cave. But if you're talking about older material, the most common method of feces being preserved, and it sounds crazy that we could actually preserve soft material like feces, but if it becomes mineralized it can preserve it in three dimensions. So the diet actually plays a major role in whether ancient feces were mineralized or not because if you're a carnivore, if you feed on vertebrates that have bones or something that has only soft tissue, either way there is phosphorus in bone, there's phosphorus in soft tissue and that can contribute to the mineral called calcium phosphate.
	And there's a lot of calcium around, so that's a little easier to come by but phosphorus is not so easy to come by. So if you are a carnivore and have a diet that has phosphorus in it, your feces are more likely to be preserved if they are deposited under the right conditions. So that means that most of the feces throughout the world in museums are mostly from carnivores which is kind of counterintuitive because there are far more herbivores than there are carnivores. But herbivore coprolites require an external source of elements that can help them be mineralized. So actually herbivore coprolites are very, very rare.
Erin Welsh	And in terms of the environmental conditions at the time or maybe environmental conditions nowadays, are their hotspots that we see around the world where there happens to be a lot of coprolite deposits?
Karen Chin	Yes, indeed the hotspot would actually be the likelihood of whether something is buried or not. And this also works in terms of preserving body fossils. Most fossils can be more easily preserved if they are rapidly buried. And that goes for feces as well because what happens is if the feces are left exposed on the surface, they can be subjected to rain, so an erosion, or animals that step on it or feed on it or other things that just decay it, it can be decayed by bacteria. If you bury the feces, you can slow bacterial decomposition. And if the conditions are right and we're still trying to understand what those conditions are, bacteria can actually facilitate mineralization of the soft material.

	And again this seems ironic because you usually think of bacteria as decaying things, but as bacteria live they can produce some substances or change the micro environment that actually facilitates mineralization. And many experiments have been done investigating the role of bacteria in mineralization and it may be that many, maybe even most processes of mineralization in place, and I'm talking about in sedimentary environment, I'm not talking about volcanics or magmas or anything, but just producing chemical minerals in place seem to be facilitated by the activity of microbes, especially bacteria.
Erin Welsh	And are those bacteria, are they environmental bacteria or like in the soil or are they internal bacteria as part of like the gut microbiome and shed along with the feces?
Karen Chin	We are still trying to figure out which bacteria can do this. The thing about feces is that feces have so many bacteria in them, there's lots. So they can be readily preserved if the conditions are right. Which bacteria? That's an excellent question. A student that I worked with, Dr. Joseph Daniel, he once did an experiment with me where he buried chunks of bone and then dripped a supersaturated solution of calcium carbonate over the bone but some of the pieces of bone had been treated to reduce the numbers of bacteria. It's hard to get rid of everything but he reduced a lot of them. In the the chunks of bone where the bacterial populations were reduced there was very little precipitation of the calcium carbonate that was percolating through the sand and around the bones.
Erin Welsh	Speaking of bacteria, most of the time when we've brought up coprolites on the podcast before it's been in the context of parasite eggs, specifically human parasite eggs that have been found in certain specimens where and when, what does that tell us about human evolution or parasite evolution. But coprolites can tell us a great deal more about the animal that produced that poo than just what parasites they may have been infected with. So what are some of the other things that we can learn from coprolites?
Karen Chin	Yes, we can learn several different things and it usually depends on the kind of preservation of the coprolite that you're examining. I think the most common source of information we look for is what was the animal eating. And sometimes we can recognize some very distinctive bits and pieces, you have to kind of think three dimensionally because quite often when you're looking at dietary residues in a coprolite, they've been chomped, they've been digested with gastric juices, and then they've probably been changed through geological processes through mineralization or by bacterial decay. So we look for bits and pieces that can give us a glimpse into who were the victims, who was eaten. Sometimes we see pieces of bones, sometimes we see pieces of shell, sometimes we see lots of leaves. And sometimes those things are very, very difficult to recognize but we're getting better and sometimes we can see just a little piece of something and say well that's a piece of bone.
	In most cases we assume that when we find something in a coprolite, it was eaten, it was food. But sometimes we can also see evidence of organisms that were visitors that visited a dung pile after it was deposited. And actually one study that I worked on with colleagues, we found over 140, I don't know, more than that, snails associated with coprolites. They were preserved in them, on top of them. And we examined how complete they were and actually found that most of them were fairly complete. So this suggested that these snails were post-depositional visitors because snails actually often feed on dung, snails and slugs, because they like the bacteria in dung. And sometimes when people are studying snails they will put dung out for bait to attract them. So that indicated that in this case even though we found snails in the coprolite, they were not necessarily eaten, it's possible that some of them were eaten but it appears that most of them visited the dung after it was deposited. So this provides another angle of interpreting the ancient environment because this shows how waste materials like dung were recycled in ancient environments.

	So we have diet, we have recycling, we can also just tell if something is eaten, it's a contemporary of the dinosaur. So we can learn who was living with the dinosaurs whether or not they were eaten. And finally, well I shouldn't say finally, we're still finding out more and more about what coprolites can tell us but I'd say of the fourth major category is when we study some coprolites we can learn how it was preserved. And a good example of this, the best example that I have worked on is when we studied a Tyrannosaur coprolite, not T. rex but a slightly smaller and older relative, probably 10 million years older than T. rex. And when we examined the coprolite, we found mineralized muscle tissue. This was just so shocking because you'd expect wait a minute, this can't be, this went through the dinosaur's gut and then it came out and and you'd think that somewhere along the way the muscle tissue was either digested or else decomposed by bacteria.
	But what this told us was that the gut residence time of the food was rather quick. If the food had just sat in the dinosaur's gut for a long period of time it would have been more completely broken down. But if it went through relatively quickly, you wouldn't necessarily have digestive juices actually attacking every little bit of what was eaten. And when I was working on this I found an article that explained that muscle tissue has been found in the feces of dogs that were fed raw meat. And you figure if a dog has a skull that's maybe, a big dog maybe has a 10 or 100 inch long skull but a Tyrannosaur could have a skull was 3 feet long and they could not chew like a dog could, they could gulp and swallow. So if there was a relatively fast gut residence time, all of those bits of food would not necessarily be digested. And then once it was deposited we have to mineralize it very quickly before all the bacteria decompose the muscle tissue.
	But again as we've learned, bacteria can facilitate mineralization and there have been scientists who have taken dead animals like dead shrimp and buried them. And they have documented mineralization of the muscle tissue within weeks. So all of these things tell us a little bit about the digestive tract, they tell us about the process of mineralization. And that was not originally why I wanted to study this Tyrannosaur coprolite, I wanted to learn about the diet but it provided such an interesting window on other kinds of aspects of the fossil record.
Erin Welsh	That must have been so thrilling to see that muscle tissue. What an unexpected finding.
Karen Chin	It was such a fun study but it was it was challenging because when I first saw it I thought that doesn't look like plant tissue, maybe it's muscle tissue. No, it can't be. It just can't be. And I'd go to bed at night thinking it's not muscle tissue. Then I'd wake up in the morning, maybe it could be. Then the next day I'd think no, it's plant tissue. And I'd wake up in the morning, no it could be muscle tissue. And so because I'm not a specialist in anatomical tissues, I sought out a colleague at Stanford who actually worked on muscle tissues and shared it with with him and Dr. Rando said yes, I think this seems to be the most likely explanation. So it was it was so surprising. But interestingly as I was looking at the microscope through thin sections of this specimen, I suspected that it was muscle tissue. But then one day I happened to make some random thin section and could actually see the myofibrillar striations in skeletal muscle tissue. But that was so serendipitous to get just the right angle and the right view. And that really helped seal our interpretation.
Erin Welsh	And so is that one of the major ways that you study coprolites is through taking this fossil and cutting tiny little slivers, little sections and putting them on a microscope? What are some of the other ways? Or if you could talk a little bit more about these methods that you use to study these coprolites.

Karen Chin

Yes. I really like making those thin sections like you explained but it is a destructive process. And before you ever do anything like that you have to first of all ask the museum for permission to destructively analyze some of a sample and you often don't necessarily want to do too much of this, especially if it's a very unique specimen. So that is one way we do microscopy on broken pieces. But one thing we are investigating now is looking using computed tomography or CT to examine what's inside. And I and my students have used X-ray computed tomography and neutron computed tomography. And one of my colleagues in Europe, Dr. Martin Qvarnström, has done exceptional work in using synchrotron radiation. And then he's been able to find really cool beetle parts in some of the coprolites and other things in some of the material he studied.

And that is really great because it's non destructive but there's pros and cons to both methods. I think sometimes you can see more in the thin section but you're only looking at a two dimensional slice and its destructive. With computed tomography you're seeing three dimensions but you may not necessarily see cellular detail that might be preserved. So we're throwing as many different techniques at these coprolites to learn as much as we can. And what we are learning these days I imagine in 20 years people will be able to deduce so much more information.

Erin Welsh

One of the things that crossed my mind was that you're able to tell so much from this coprolite. But how can you use that information to help you determine what animal it might have come from? Is it just from the coprolite itself or is it also from what else you find in the area?

Karen Chin

Yes. This is another time when we use multiple lines of evidence. The most important line of evidence is what is the age of the sediments. So if I'm looking at Cretaceous age sediments, I know that only a certain number of animals could have produced it. I won't say it could have been produced by a wooly mammoth because they didn't live in the Cretaceous. And then you can you can fine tune that so that when you find a coprolite, you're looking at maybe just what are the contemporaneous organisms that we find in the sediments of the same age? So that is one line of evidence. Another line of evidence is the size. If you find a really large fecal deposit, you know it wasn't produced by a small rodent-sized mammal. If you find a small piece, that's a little more difficult because small pieces can come off of a larger fecal mass. And there are we know things like deer and rabbits that often produce pellet groups. The complete pellet mass is different from the mass of one of those little pellets.

The size is helpful and then what is inside, if we find bone inside, we know we're not looking at an herbivore. So you use all of those different lines of evidence. And when we actually studied a very likely T. rex coprolite, we measured the volume of it and it seemed to be about 2.5 liters in volume, roughly 2.5 quarts. And this would be a very large fecal mass. So we looked at well who lived in those sediments that was a carnivore, since we knew there was bone in there.

And we found that many of the animals fell into kind of two groups. One were carnivores that were maybe a couple hundred pounds roughly and then there was a T. Rex that was much, much larger. So between looking at the animals that lived at the same time, the fact that there was bone in the diet, the size, we were pretty confident that this fecal mass was produced by T. rex. But with a coke or a light, you often will never know. It's quite possible that a large animal that was not T. rex passed through the area at the time, defecated, and did not leave any bones behind. So always when we talk about who produced the coprolite, I always put probable coprolite from such and such an animal in front of it.

Erin Welsh

I love the idea of a big dino just passing through and just dropping off a coprolite and keep going and leaving people nowadays like what could that have been besides T. rex?

Karen Chin

Exactly.

Erin Welsh	And so that that T. rex, that likely, that probable T. rex turd, is that the largest coprolite found?
Karen Chin	No, no, we've since found coprolites that are on the order of 6-8 liters in volume and that's just the ones that I have looked at, I know other people keep finding large coprolites that may or may not be published at this point. But I'd say those are among the largest we found.
Erin Welsh	So you've talked about two Tyrannosaur coprolite stories which I think are super fascinating but I wanted to ask you also about another of your groundbreaking findings which is the duck-billed coprolites from the Two Medicine Formation. What did you learn from these coprolites about duck-billed diet and maybe dung beetles?
Karen Chin	Yes, this was one of my favorite studies. We found, well I should say it was my boss and mentor Dr. Jack Horner that originally found these weird rocks that had lots of plant tissues in them. So for my doctoral dissertation, I studied what is the evidence that these are actually coprolites like Jack thought they were? And we found good evidence that they were from the geological evidence and the contents. But another aspect of these coprolites that was so interesting is that many of them had burrows in them. And I immediately thought dung beetles. But then I thought well I'd never be able to tell a dung beetle burrow from a worm burrow, so I can't say that these are dung beetle burrows.
	But when I was studying this project I was contacted by Dr. Bruce Gill who was a dung beetle specialist from Canada. And he asked about the burrows and I just said well yeah there's burrows but we can never tell who produced him. And he said well why don't you send me some photographs? And I did and he explained that these burrows are very distinctive and in modern environments we don't have animals that backfill sediment with dung to provision these brood masses for the young beetles that will be growing up. And so the dung beetle burrows have very distinctive features. And he looked at him and said those are dung beetle burrows. And so that was really a lot of fun because it linked the dinosaurs not only with the plants they ate, but with the community of recyclers. We studied these burrows before we found the snails but as we keep learning about these animals that are associated with the dung, that actually opens up more and more intriguing views of the ancient environment.
	In fact not only did we have the dung beetles but these these coprolites were filled with wood, conifer wood. And my first publication, I thought well if these dinosaurs are feeding on conifers, cone-bearing trees with very short needles, say like junipers or other kinds of conifers with very little leaves, of course they're going to eat lots of wood. But after further study I realized that the pieces of wood did not correspond to the branches that you would expect if they were feeding on the leaves. And after more study of the cellular structure of the wood, it became evident that the dinosaurs had actually ingested rotted wood. And this seems surprising, a lot of people will say well the structure of the cells occurred in the dinosaur's stomach. But it gets a little complicated but I'll just say in order to get the cell structure we found, you have to destroy a component in wood called lignin. But to do that it requires oxygen. So that cannot happen in a vertebrate gut.
	So the structure that we find in the coprolites where you find the cell structures are broken apart could only have been done by a white rot fungus that would have occurred before the dinosaurs ingested it. So then you say well why were they eating wood? It doesn't make sense. But when you decay would with fungus, you actually make cellulose available. So the wood becomes more nutritious. But still why would they eat wood when they could go out and eat leaves? Because there's cellulose and leaves and that seems like an easier source of cellulose. But at this point in time our best hypothesis is that the dinosaurs were nesting and required sources of protein to help support when they laid eggs, they needed to add enough protein to those eggs.

	And if you're a big herbivore, probably the best place that you're going to find a reliable source of protein that you can actually catch since you're not a carnivore, would be something like rotting wood where there'd be termites and crustaceans and all kinds of very interesting animals in there. So again we have the dinosaurs, we have the conifer wood, we have the white rot fungi, we have the dung beetle activity, we have the snails. And then some colleagues found comparable coprolites in Southern Utah and in those coprolites there were pieces of crustacean. So this really kind of supported the idea that yeah, these animals even though they were herbivores did occasionally eat animals, just like most birds, even if they're mostly herbivorous, they will often change their diet when they are getting ready to reproduce.
Erin Welsh	That is so incredible how you can build this world and paint this picture from these fossils, this fossilized poop. It's so beautiful, I love it. I just love that, that's amazing.
Karen Chin	I think it's pretty cool, yeah. And oftentimes people well think that coprolites can't tell us that much. And they're right, some coprolites do not tell us that much but some coprolites just because of what they're composed of and how they're preserved can provide incredible snapshots that give us a view on ancient life.
Erin Welsh	We're going to take a quick break here and when we get back I want to hear all about how you were introduced to this incredible world of coprolites.
TPWKY	(transition theme)
Erin Welsh	Welcome back everyone. I've been really enjoying hearing all about the science of coprolites but now I want to hear about you. How did you become interested in fossils in the first place? Were you one of those kids that just loved dinosaurs or did that love kind of spark later on?
Karen Chin	I really thought dinosaurs were cool. When I was growing up I had, like many young kids, I had a dinosaur book. But I never really thought and I never really envisioned myself studying dinosaurs when I grew up. I was interested in the modern world, you can walk out your door look at plants and animals and I just thought it would be so frustrating to try to study something that we could never see again. So I was really quite surprised by my reaction when I started working for Dr. Jack Horner. I was working as a preparator cleaning and gluing dinosaur bones together. And then I went out and visited their field camps and I started also researching paleontology to help write text for the exhibits. And the more I learned about it the more I was hooked. I just couldn't get enough of it. And it was so ironic because again I never thought that I would study something like that because I really thought it would be too frustrating but instead different people have different affinities for different subjects. And I found that this studying paleontology really fit the way I think.
Erin Welsh	And when did coprolites come onto the scene? What was the first coprolite that you remember looking at or studying?

Karen Chin	That would be the ones from the Two Medicine Formation that Jack found. And I never even thought that feces could be fossilized. It wasn't until I was reading and writing exhibit text that I learned that people had found it. And so I ran to talk to Jack and I said did you know that people have found fossilized feces? And he said, 'Well yeah and I found some too.' And I was just shocked. And so at the time I was working as his histological technician, so I was cutting up bone pieces to look at the patterns of vascular tissue so he could make inferences about physiology and phylogeny of dinosaurs. So I was already used to cutting mineralized samples. So I said well can I cut a piece of this and make a thin section? And he gave me permission to do so. And when I looked into the microscope, I looked at that slide, I could see ancient plant cells. And it just kind of was a real thrill because I realized I was looking at evidence of plant dinosaur interactions and what a cool way to look at how dinosaurs interacted with with other organisms and environment. And that's when I got hooked.
Erin Welsh	You are an absolute pioneer in the field of coprolites. How have you seen this field change over the course of your career, either in terms of technology or just generally speaking?
Karen Chin	Well I have found some interesting things, studied some interesting projects in coprolites. But I would like to point out that people knew about fossilized feces before they had ever named dinosaurs. So over 100 years and there have been many, many people who have done some really cool work on coprolites. So I don't want to claim I'm the only person that was studying them, lots of people have studied them. But I will say that studying coprolites is not easy, it's really hard and it can be very frustrating because unlike with a with a bone, you can pick up a bone and you say okay that's a bone and I can figure out who it was or a shell or wood. But when you pick up something that you think is a coprolite, first you have to say well wait a minute, what is the evidence that this is fossil feces?
	Some of the material we look at is and some of it isn't. And then you may look at it and find nothing recognizable in it and you may not know who produced it. So it's really, really challenging. So it helps if you're studying some really spectacular examples and I have been lucky to study some of those spectacular examples. But I think that these days now people are looking at some of the even more difficult ones to study and they have been making conclusions, examining specimens that I may not have started to study before and finding new things, just documenting things all over the world. People all over the world are studying coprolites and like I mentioned my colleague is using synchrotron radiation and people are looking at other ways to study them. So I think it's really an exciting time for trace fossils because quite often body fossils get most of the attention because they tell us about great big or weird animals. But coprolites, they're interesting but they are more challenging to study. And I'm so pleased that more and more people are studying them these days.
Erin Welsh	One of the things that I really admire about you is just how much outreach and science communication that you do. Can you talk about why you feel it is important for scientists to connect with the public and share their work?
Karen Chin	I think sometimes people think of science as being a black box, that scientists have these answers to things that maybe some people may not understand how we came to those answers. So I like talking about my work because it's easy for people to get excited, especially kids, about dinosaurs. And when you throw in something like dinosaur feces, it's even a better hook to get people saying well that's weird, how can you learn about that? So then when I talk about my work they can get an idea of how the process of science works and it might be more approachable for them. And I think this is very important because we all should know more about the way science works and why we know what we do so that when we get information about changing environments or decisions that have to be made that relate to science, we are better educated ourselves. So I think it's very important for all of us to to get an idea of the critical thinking that goes into conducting science and that people understand that we're not pulling weird facts out of the air, that we do evidence-based research.

Erin Welsh	What are some misconceptions about paleontology or paleontologists that the general public might have that you would like to correct?
Karen Chin	Oh I don't know that there's anything really critical. I'd say that a common misconception sometimes is people think that paleontologists and archaeologists are the same, where paleontologists study ancient organisms, nonhuman organisms, and archaeologists study human organisms. But I don't even mind if people call me an archaeologist because they know we study all things. And that's fine. Another common misconception and again I don't think it's a bad thing is that people often think we get to spend all of our time out in the field with our pick in hand and finding new stuff and that is so much fun to do. And I should say that I have colleagues that can spend months and months out of the year but for the rest of us, many of us have to spend more time than we'd like to admit sitting in front of a computer trying to write up or describe our results. So it can sound very glamorous and some of my colleagues do have a very glamorous lifestyle but for the rest of us sometimes we get to go out in the field for a little while and then spend the rest of the time in front of the computer. But again I don't mind these misconceptions because I think I just am happy when people are interested in science.
Erin Welsh	Do you feel that graduate students in paleontology are getting enough training in communicating their science to the general public?
Karen Chin	I do think I see more and more interest in graduate students in learning techniques to communicate the science. I really do think that there is a growing awareness of how important it is to communicate science. And I'm delighted to see many graduate students volunteer to work in museums, to do outreach with people, to go out in the community. And that's a development that I'm delighted about.
Erin Welsh	I've got just one more question for you before I let you go. Do you happen to have a favorite coprolite pun? I'm sure you've heard many over the years.
Karen Chin	Okay well I'll tell you my oldest one and because it's the oldest one, I know some of my friends tend to groan every time they hear it but I'll risk that if they happen to hear this. Coprolites are very challenging to study as I mentioned and because you often do not know first of all if it's a coprolite or who produced it. So I often like to tell people that my work is challenging because when I study a coprolite I may not know who dung it. (laughs)
Erin Welsh	(laughs)
TPWKY	(transition theme)
Erin Welsh	Thank you so much for joining me today Dr. Chin. Coprolites are even cooler than I expected them to be and I had some pretty high expectations. And I am so excited to do some more reading on the amazing world of fossilized feces. And if you two would like to learn more about the who, the what, the how, and the why of coprolites, check out the post for this episode on our website thispodcastwillkillyou.com where I'll link to a few papers by Dr. Chin. Also on our website are the sources for all of our episodes, transcripts, quarantini and placeborita recipes, our bookshop.org affiliate account, Goodreads list, links to music by Bloodmobile, links to merch and Patreon, and so much more.

Listen, follow, and leave us a review on Amazon Music, Apple Podcasts, or wherever you get your podcasts. And don't forget you can listen to new episodes one week early on Amazon Music or early and ad free by subscribing to Wondery Plus in the Wondery app. Thanks again to Bloodmobile for providing the music for this and all of our episodes. And thank you to you, listeners. I hope you enjoyed this deep dive into dino poop. And a special thank you as always to our wonderful, generous patrons, we appreciate you so much. We've got a brand new episode on a brand new topic coming out next week. So until then keep washing those hands.