Have Beans, Will Travel

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Introduction
Beans, beans! They're good for the heart! In this month's episode we are joined by two specialists from the EXARC Experimental Archaeology Award winning project Investigating the Origin of the Common Bean in the New World. We hear about the difficulties identifying beans in the archaeological record and how using organic residue analysis might begin to spill the beans… on beans. **Timothy Baumann** is the lead investigator on the project. His research interests in experimental archaeology focus mainly on prehistoric and historic foodways, pottery and tools from the south-eastern United States, which is where the idea for the project came from. **Eleanora Reber** is a Professor of Archaeology at the University of North Carolina Wilmington and Interim Chair of the International Studies Department.

Transcript
It's the first Friday of the month, which means that it's time for the next episode of #FinallyFriday, bringing you insights and discussions from around the world focussing on experimental archaeology, ancient technology, archaeological open-air museums and interpretation.

Phoebe: Hello and welcome to #FinallyFriday. My name is Phoebe Baker, and today I'm joined by two specialists from the EXARC Experimental Archaeology Award-winning project, investigating the origin of the common bean in the New World. This project aims to track the origins of the common

bean in the New World through the use of experimental archaeology and organic residue analysis. The team hopes to use their findings to start providing new methodologies for the identification and interpretation of early bean usage.

Timothy Baumann is the lead investigator on the project. His research interest in experimental archaeology focussed mainly on prehistoric and historic foodways, pottery and tools from the southeastern United States, which is where the idea for the project came from. Tim is also the former director of the University of Tennessee's Laboratory for Environmental Archaeology and curator of archaeology at the University of Tennessee's McClung Museum of Natural History and Culture.

Eleanor Reber is a Professor of Archaeology at the University of North Carolina Wilmington and Interim Chair of the International Studies Department. She is also a specialist in organic residue analysis and her lab, the UNCW Pottery Residue Lab, is a dedicated facility for gas chromatography–mass spectrometry analysis of absorbed and visible pottery residue analysis. Nora has research interest in plant domestication and agriculture and she plays an important role in the project as lead in absorbed residue analysis.

So welcome both of you. This sounds like a really, really interesting project and I'm excited to get a little bit into it. So I've got a quick question to start you off, well, the question is quick, but the answer might not be, which is: why study beans? Tim, would you like to start?

Tim: Yeah. Thanks Phoebe. This has been something that's been close to my heart or stomach - however you want to say, there's a lot of bean jokes that got involved in this - but beans are very interesting in as far as archaeology research in that it hasn't been really a major focus. And the common bean, or a lot of people think of the kidney bean or things like that, is a New World domesticated plant that really is domesticated, we think twice, first in South America and then in Mexico. But its arrival in North America, north of Mexico, how it arrived, how it was transported in the timetable, and why it was adopted into societies and pre-contact America has always been somewhat of a mystery and part of why that hasn't been studied as much is twofold. One, everyone was maize-happy looking at corn, corn and more corn. And the other thing was that beans don't survive very well archaeologically. If you eat a bean, you eat the whole thing, so there's nothing really left to potentially discover unless you accidentally burn some in the fire or something of that nature. But even then the beans are very fragmented and can just fall apart in pieces right in front of your eyes. And we don't have good evidence of that. So, I mean, there's plenty of discussion we'll have today, I think, about why or why not beans were important and why they're adopted and so forth. But I think the real question for me is, when did they get here and how did they get here?

Phoebe: It sounds like they definitely need to be studied, often overlooked. Do you have anything to add, Nora?

Nora: Well, I think Tim brings up an important point about the preservation of the beans. I personally like maize as much as the next person and more than many, I suspect. But, maize is in a lot of ways easier to find both because it undergoes parching and preserves in the ethnobotanical record, but then also because it's got this unique photosynthetic pathway, the C4 pathway, which is unusual in the southeast and Midwestern United States. And so you can get at it through stable isotopes in the bones and even the residues, whereas beans don't have that distinctive trait and are harder to find in terms of the chemical archaeology as well.

Phoebe: So in the past have beans kind of been more limited to chance finds, like you said, Tim, burnt in a fire?

Tim: Yes, you're right. There's two levels of preservation, how they've been discovered. The preservation of just being carbonised is the number one way that the beans might be preserved. There are some examples of some desiccated pre-contact beans found in dry rock shelters and caves, particularly in Arkansas. And if you looked at them, they looked like they were just put in there last week. They still have the seed coat and everything. They're pretty amazing. But that's as rare as can be. In most cases they are carbonised on a house floor that burned or in a fire hearth or may have been swept off the floor as they're doing cleaning and put in quickly buried deposits like in posts that have been reset in a house. And sometimes we're finding those in the post holes once they redo those pretty quickly. But in general, the history of archaeology and at least the United States is that there really wasn't a focus on collecting plant remains until, really, the 1960s with the development of flotation and after that the earliest work, here where I've been working here in Tennessee in the 1930s up through the 1960s, they really didn't collect plant remains. Or if you were lucky, they might collect a little fragment of some matting. So I think that's part of the problem, just the collection strategies and methods have been flawed. Even in modern terms, if you do use flotation and run some soil through a water filtration device, that water and that churning part will just break that bean up into a thousand pieces and you won't really see it. The best preservation is just hand excavation, slowly piece plotting things in context, in a house floor, or in a feature that you can pull it out at the site itself. That's where the best preservation recovery method has been and that, again, has been more recent in the last, 40-50 years, that has been more precise. But even so, there are a lot of other beans and I know Nora knows this quite well, that are still probably undiscovered sitting on shelves and museums from unprocessed soil samples, flotation samples and so forth, that had never gone through completely. So I'm sure there's more beans to be found that already are out of the ground, but plant analysis always seems to be the last thing that a budget will cover, as opposed to stone tools or pottery that are usually at the top of the list.

Phoebe: Even though it can tell us such interesting things…

Tim: Well, part of that is that somebody like Nora who has a very unique special expertise in residue analysis. Similarly, plant analysis is a unique skill. A general archaeologist can look at a piece of pottery and say what it is, but most archaeologists can't identify what kind of species a plant is or a seed sometimes. So in that case hiring a specialist requires extra money, somebody else than the primary archaeologist. Plus, that's why this grant that we were able to get through EXARC is so important because it allows me, a general archaeologist who has interest in these topics, to work together with a specialist like Nora, who actually provides additional skills to help - hopefully -understand these beans a little bit better.

Phoebe: Well, that brings me onto kind of a follow up question, which is, what kind of questions can you actually answer through looking at bean consumption? I guess obviously you can answer are they eating beans? But are there kind of more wider cultural questions that you can also answer?

Tim: Right now the idea of the beans coming into what we think of the United States came through the southwest around 5,000 BC and then they sort of get stuck there and don't really cross over the Rocky Mountains for about a thousand years and go through The Plains and northern Plains and through the Great Lakes as our current route that we believe it goes. And once it gets to the Great Lakes, goes up through New York and down the Ohio River Valley and then comes to the southeast last and that's based upon directly dating beans that the people have done. When I started this project looking at beans, six years ago, there really wasn't anybody doing anything in the southeast United States. And so we really didn't understand if beans came just from the northern area that sort of roundabout, down the Ohio Valley into the southeast or if there was another route across going directly east-west or west-east or along the coast. And so that's the first problem of trying to

do that. But the adoption of beans in the Great Lakes, in The Plains was, you're seeing something that part of what's called the Three Sisters agricultural system, where it's combining… you're planting beans along with corn and squash together in mounted garden plots. And what's happening is that they're helping each other grow in that the pole beans of these common bean varieties would grow on the corn stalk, using it as a growing pole and then the ground cover of the squash would help to keep down the weeds and maintain that. They also help each other as far as putting nutrients back in the soil and combined together to actually make a good collaborative growing environment. Those three plants become the focal point in the late pre-contact period of domesticated plants eaten. Again, corn has always been king as far as studies go. Beans and squash have been secondary and I think it's really important to try to understand why they were brought in and then why we see beans being eventually adopted in the southeast, which is culturally speaking, different linguistic groups, material culturalized different and what we call the mid-south and deep south Mississippian time period, Mississippian cultural period, those in the Great Lakes area, you're seeing some Mississippian folks stretching up that far. But we're getting something called the Fort Ancient Oneota cultures, which are much more gardening atmosphere. So for that being said, there's a lot more social dynamics of interaction between these different cultural groups pre-contact that we don't really know about and these beans might provide a window of that relationship, along with some other factors we can get into today.

Nora: Yeah, and I would say that, to some extent, we're not far enough along to quite know what we can learn yet. Until there's a really kind of reproducible way to detect beans in the archaeological record, we won't really know in a lot of ways what questions we can reasonably ask, particularly with respect to ritual meanings, these social aspects that Tim was talking about. So I could expect, if we or someone else came up with a good, reliable way to look for beans we could then start looking at cultural meanings of it, like people have with corn. And you could match it up with artistic and iconographic studies as well, but we're just not quite there yet, which is why this is a really important study in a lot of ways.

Tim: Nora's right, there is a lot of folklore, much more as far as imagery dealing with corn. There is a little bit with beans, but nowhere near what we know about corn as far as culturally speaking.

Phoebe: They are some really interesting points, thank you very much. So to get more into your actual experiments, could you give me a bit of a rundown of the methodology for the project? How are you bringing experimental archaeology into this? It sounds like it's going to be really helpful and important.

Tim: This is an idea I came up with a few years ago and I've talked to Nora about and finally got some funding to try it out. And that is, is there a different way to identify beans, as Nora just said, other than just finding the physical bean in the ground or the carbonised bean or even potentially desiccated one? And since they don't preserve very well, and so, working with Nora previously on other projects, I'm like, well, there should have been some bean residue if it's being cooked or stored in a pot that should have been absorbed in these vessels. Maybe there is a way that we can identify the biochemical markers, the signature of these beans, what they might leave inside of a pot. And we're not talking about so much the surface residue - again, Nora can talk more about the science of this - but they absorb what actually penetrates into the vessel wall that she has a method of extracting and if we can do that and be able to find a way to say, aha, there was beans in this pot at some point, that we might be able to track how important beans were at a specific archaeological site or within a cultural region or area, or how it entered… rather than right now, I can literally put all the carbonised beans that were found in the state of Tennessee, for example, in my two hands together, and I could probably put all the beans found in the entire southeast in one standardised

box. So there's not a lot of beans. So that's why this is probably…, finding another method to track beans is so important. So thus trying to find an experiment and talking to Nora about how to go about doing that, then she helped me to get over a lot of those speed bumps to try to replicate, to develop an experiment rather than jumping in straight into, all right, let's just guess, and pick up a pot sherd from a burnt house floor that had beans and hope that there's beans in it. I think the key to all this was to try to identify that we cook some sherds or a pot with beans that we know that's the only thing ever been cooked in that pot. And so if there's any residue in it, it has to be from beans. That's trying to see if there is something in that we can identify as a marker that we can then test on real pre-contact sherds from the southeast and other areas.

Nora: I remember some of the other sherds also included, I think, was it deer and what else was in there?

Tim: Right. So we had two sets of sherds we wound up doing as far as our methodology. We were able to get a replica pre-contact Mississippian era pot which was made by a contemporary potter who uses traditional methods and clays and tempering so it's identical shape and so forth and cooked on an open fire no different than they did 2000 years ago. But, she gave me one that had broken and we took 10 sherds and then cooked five of those with beans only on a Bunsen burner kind of thing, or a stovetop burner and then cooked another five sherds along with corn and beans and deer meat and that was done at Nora's suggestion as well as we talked about, is there a way to still see beans when you have other things cooked with it? That wouldn't potentially mask it. Things like the terrestrial animals like the deer meat might have a lot more fat and lipids that would sort of mask that completely, not even see it. We don't know. So I think that's part of it that we can't assume that they're just eating… putting beans in a pot and cooking it pre-historically or pre-contact periods that they're probably mixing it in some sort of stew with other things, might be a possibility. So we need to be able to find other ways to extract that, even when there is a clouded mess of other objects and other materials that are in the residue.

Phoebe: So you are really trying to build up a reference collection for this kind of thing, sounds cool. It sounds like from what you've said quite a lot of the research so far has been done in quite a lab-based setting in terms of using the Bunsen burner. Do you have any plans to move it into kind of a more actualistic setting with like a whole pot and an open fire? Do you think that will make much difference?

Tim: I think the key to having it in a laboratory setting is to control any contaminants as little as possible and control the environment. When we're doing residue analysis, let Nora explain that of issues of maintaining, lessening contamination and making sure that whatever we get we can definitively say something.

Nora: Yeah, I don't think it should make a massive difference. There probably would be some difference in absorption patterns. So when you're looking at prehistoric pots or like the pots that were used in this study, they're unglazed and so they're sort of like a terracotta flower pot and they've got all kinds of pores. The foods cooked in the pot will normally kind of soak in from the inside, right? Because that's where the ingredients are. Whereas you won't get many residues on the outside of the pot because that part will be exposed to the heat and anything that gets there will be burning off. And it might also be contacted by ash and so on, whereas things that were cooked in the lab like these, I'd expect the experimentally produced foods to absorb within the sherd evenly all over. But chemically, I would expect the same thing to happen. So I would expect the same sorts of compounds to absorb within the pot, just evenly all over the pot instead of just from the inside.

Phoebe: And that's because the sherds are cooked inside the stew rather than being a vessel for the stew.

Nora: Yeah, exactly.

Phoebe: And, would you expect to, of course beans are likely to have been cooked in things like pottery, but do you ever find lipid analysis on other materials? Could there be anything else that you could look at to look at bean residue?

Nora: Oh, it's very tricky. You actually put your finger on a major problem in residue analysis. The reason pottery works as well as it does, is because basically when you fire the pot, it burns out all the chemicals that were once in the soil. So pretty much everything in the natural world is chock-full of lipids, just like fats and lipids and waxes everywhere. You can't avoid it. But when clay is fired into pottery, all those natural lipids are burned right out in the firing process. And there's been experimental work done by Professor Evershed and by others, including me to some extent. So when the pot is fired, it's sort of a blank slate and the only things that get in there got there after it was fired. So that doesn't always mean it was from its use, but it's helpful, right? It's a starting line. People have attempted to do residues from a variety of other things, rocks for example, like grinding stones and you can do some things with surface lipids maybe. But really starches are better for that, because the problem is that rocks also have lipids. We don't think about them having them, but they have lipids. And so distinguishing the lipids from whatever was ground on the grindstone with whatever lipids were natural to the rock, it's maybe doable, but it's very, very tricky. Certainly much more complicated than just looking at a pot sherd and being like, yep, there's lipids in there and they came from after it was fired. People have done some interesting things with, for example, shell cups, but you have to be very, very careful. Because if you imagine the sea creature building that shell around its body, which is kind of what they do, lipids are involved in this. So like I say, they're everywhere. So when you're looking at residues from shell cups, you have to make sure actually, that you're probably not looking for normal lipids. Where shell cups have been studied most usefully is when you're looking for something with some really unique compound in it that does not naturally exist in shellfish. So for example, you can look for black drink or caffeine-containing beverages in shell cups. Because there is no shellfish that extrudes caffeine. So if you find caffeine, it must be either from the shell cups' use or maybe from a spill in the lab later. That's a totally separate issue. Similarly, you can look in shell cups for other compounds that are unique, and not present in shellfish, like for example, atropine and scopolamine, which are present in Datura. But again, not present in shellfish. So you have to be really, really careful. Whenever you look at some non-pottery item for residues, you have to be really intentional about what lipids might be there naturally and how those natural lipids may or may not be different from what you're looking for. So it's kind of a 'yes, but' answer.

Phoebe: That's a really interesting answer. I had no idea that rocks had lipids in as well.

Nora: They do. Tammy Buonasera did some really interesting studies on it, actually, in the Journal of Archaeological Sciences.

Phoebe: Oh, I'll have to take a look at them. Speaking about, looking at lipids in the vessels brings me onto what types of foods are best usually to identify through organic residue analysis. So thinking more about the things in the vessels now.

Nora: Right, so normally unique foods. So, you know, I've just said lipids are in everything. So pretty much every food has lipids and often they're pretty…, I mean, they're not identical, obviously, fresh foods, you can distinguish the different food types by just looking at the lipids and the fatty acids

present. But once they've sat in the ground for a while, they undergo all these chemical reactions, oxidation and hydrolysis and microbial breakdown. And so pretty much a lot of the lipids start to look like each other, and you can't easily distinguish the original components just from the fats. So you have to look for something called biomarkers. Those are compounds that are unique to either a food itself, like a specific food, like, caffeine is unique to black drink in the southeast. Or to coffee in Northern Africa or to chocolate in Mesoamerica and so on, or to something that's unique to a category. So if you think about sitosterol, that's unique to plants. So if we find that, we know there was a plant, but we don't know which one really. So the more unique the food stuff in terms of its chemistry, the better. Things with a little bit of a, I guess, a kick, like caffeine-containing beverages, hot peppers, Datura, most psychoactives if you're really thoughtful about it. But, you know, these aren't really foods most of the time. Tobacco, you can see that very nicely. But in terms of just regular old foods which you just might normally eat for breakfast or lunch, many of them after they've been in the ground for a hundred years or so, you can sort of tell whether it was mostly plant or mostly meat. And it can be quite tricky to distinguish the unique food stuffs feeding into the residue, which is one of the reasons I really wanted Tim to do this experimental portion of the study with the beans and the corn and the deer, because I wanted to see if the bean lipids would look and sort of blend into the corn, so they all look the same, like just generic plant, or whether we could distinguish them in some way, which is of course our hope.

Tim: Nora always tells me that - or other archaeologist too - that she liked to crush our dreams in that we were always hoping for this ‘Oh yeah, I can see exactly that there was five of these kind of plants in there. This one, that one, that one’. As you said, Nora, it is not that simple and I think just because there is residue in there doesn't mean you can narrow it down to a specific species sometimes, particularly if it's everyday foods. And that's what part of the problem of looking for beans is: can we actually see them and pull them out? Whatever other type of other plants or things that might be in the way. So I think residue is not a clear picture. It is not simple and I think we make that clear to everyone else that it's not a simple task to try to pull it apart.

Nora: We do know from looking at a lot of residues from the southeastern United States, which has been one of the focuses of my lab through the years, that the residues on average look more like they're containing more plant resources than comparable studies done by my colleagues in Europe or the UK. They tend to be finding a lot more meat, dairy type of things, whereas in the southeast it's an awful lot of plants, but you don't know how many of these plants are beans and how much is corn and how much is nuts, for example, or squash.

Phoebe: I wonder why there could be differences like that between populations.

Nora: I have a lot of hypotheses, but you never really know. There are no domesticated animals except for dogs and maybe turkeys in the southeast. So, dairy is not happening here. People just going out and killing a cow for special occasions, whereas there are these huge nut stands. The agriculture's really explicitly focussed on plants here as opposed to being mixed with domesticated animals. So that may be part of it.

Phoebe: Yeah, of course, and am I right in thinking, Tim, that as part of the experimental program, you are intending to bury some of these sherds?

Tim: Well, again, this was something that Nora had talked to me about, of trying to bury some of the sherds in the ground for at least a month and talking about the natural deterioration or how some of the residue might be leached out around just groundwater and things of that nature. And then we put two sherds in a freezer to sort of maintain what they were, the preservation and such. So that's sort of a secondary project that Nora suggested, because when you go dig up an archaeological

site, of course, it's been in the ground for hundreds, thousands plus years. And obviously we're trying to replicate some of that deterioration from just sitting in the ground just to see what kind of changes may take place. So we did do that experiment, and that's a secondary one as far as preservation of the residue itself.

Nora: Yeah, I'm a really big fan of this in terms of experimental work because so many compounds are washed out in the rainfall and are dealt with through microbes and people have done a lot of really interesting studies through the years mimicking this. But I've really found it most fruitful to just bury the things and let nature do what it does and usually a month. I did a study way back in the day in graduate school and we found that most of the reactions that were gonna happen to a residue were pretty much mostly done after a month. Obviously there will be more changes after that, but a month is a nice compromise between time and learning things.

Phoebe: Sounds like it'll be a good part of the project and helpful, obviously because everything's been buried. I had a question, but I think you've kind of answered it, which was how easy are beans to identify through lipid analysis? Do you think that you could eventually, when techniques get better, maybe, be able to identify particular types of beans? I know you've said you're looking at the common bean in particular.

Nora: Determining different types of beans through residue work is extraordinarily difficult. I never say never, but if we got to that point, it might be some time. Now DNA analysis, it may be someone could do something with that through time.

Phoebe: I was gonna ask you about this actually. Do you think that there are any kind of alternative biomolecular analyses that might be applied or combined with lipid analysis to help you with this kind of thing? As you said, there's been some crazy studies come out with DNA in the last… I mean, as a palaeolithic archaeologist, DNA seems to be crazier and crazier every year with what they're finding. Do you have any thoughts?

Tim: Good that you brought that up. That was another pilot project we did a year and a half ago where we did do some DNA. We took contemporary common bean varieties, nine of them. And then we were able to get one desiccated bean, that we were able to get a radiocarbon date that was from the 16th century, from Arkansas to throw in to try to develop some DNA to see what they look like. And we used nine common varieties that had heirloom. When I say heirloom, we're talking about things that actually had either oral history or written history that connected specifically to a Pueblo village in the southwest or to a Plains tribe and so forth and tried to see if we can look at these older varieties and see what kind of DNA sequencing we can do. There's been a little bit of work done on DNA of the common bean, but no one's fully flushed it out. And that's sort of again, part of our larger study that we've been working with our colleagues …. University of Tennessee's biochemists who have been looking at some of the aspects of that in the DNA to try to get a better understanding of beans overall. So, yeah, I think there's definitely some other routes we can go and then DNA is definitely one of them. And on a side note, which is quite interesting, the DNA isn't just about size, shape, it's also the taste. There are almost 200 varieties of the common bean and the one that we wound up using for our experiment, by the way, is called the Cherokee Trail of Tears bean. And that bean, the oral tradition of that is that was a bean that was from this area, east Tennessee, North Carolina, that was carried on the Trail of Tears, which was the forced march that president Andrew Jackson forced the Cherokee and a number of other southeastern tribes to move out to the Indian territory which is today Oklahoma. And so that this bean was carried out there and it was passed on from one generation to the next and eventually was commercialised in some respects, but, mostly as an heirloom, through a seed saver company. And that's what we used to try

to look at an older bean variety that would've been potentially around earlier. But yeah, so DNA and trying to look at heirlooms, and the different varieties that are out there and so the DNA isn't just about size and shape, but there also is a taste to that as well.

Nora: Yeah, maybe starch analysis would be helpful too. If you had a visible residue and not an absorbed one.

Tim: That's something that Nora and I also looked at, that we rely so much on excavations of vessels and pot sherds that occurred 70, 80 years ago that some of those sherds actually are still viable for residue analysis, but they were scrubbed to death. So any first surface residue is usually long gone. So this is something that I'm sure Nora has advocated for her other people she's tried to work with or encouraged them to talk about residue analysis before they ever go out in the field as a possible research strategy, or be it surface residue or absorb. After the fact, it might be too late contamination-wise, or you scrape stuff away. I think it'll really have to be part of a research design before we ever go out in the field. That is something that you want to budget for and try to do the best extraction methods out in the field. Otherwise, you're gonna maybe miss the opportunity, and I think that's part of the problem that most general archaeologists in the United States anyway, are not doing projects specifically to do for residue. They think of it as an afterthought and I think that's problematic.

Phoebe: That's a nice point to bring up, actually. I wanted to ask more about, kind of project design and how you need to think about contamination. You've talked about using older specimens from museums and things. Are there issues with contamination in using those kind of things?

Nora: Yeah, but it can be quite unique and strange. So standard archaeological contamination, if you wanna think about it that way, usually sort of falls into three buckets. You have your plasticizer from your plastic bags, you have your bug sprays and then you have your sunscreens. And then if you're really unlucky, you might have some sort of a labelling compound on there too, which is sort of unfortunate. And of these the plasticizers are easiest to deal with in a lot of ways. Once you get particularly into sunscreens, the ones that are designed like you rub 'em on, those are not great for residues because they include a lot of lipids to help them absorb in the skin. So those are particularly difficult to work around because at that point you don't know which of your lipids are from the sunscreen and which are from the archaeological residue itself. And then museums can have a variety of other things sort of depending on how they were stored. Open-shelf items are actually pretty notorious for being contaminated by caffeine, because people will often have a coffee pot at their desk or maybe in the shelving area somewhere and the caffeine will aerosolise and settle on the vessels. So that's a problem. But then there are also things from various treatments over the years that people may have done to the vessels that, you know, were cutting edge at the time. But now you look at the residues and are like, Ooh, what's that?

Tim: That reminds me, Nora, of some of the things that we find. We go through museum collections that have been around for 80 years of just changing work habits and you mentioned the coffee pot, but smoking was allowed, pipe smoking, cigarette smoking anywhere within the museum in curation space. So nicotine, I'm assuming, would be some contaminants that you might find in museum collections.

Nora: Yeah, particularly the open-shelved ones. If they're closed, that's better. But plastic bags actually start breaking down after, I don't know what, 15-20 years. And then the plasticizer contamination gets even worse.

Phoebe: Are there ways that you can deal with contamination or is it once it's contaminated, it's useless?

Nora: You can work around a lot of things. Part of our lab procedure is whenever we have a sample, one of the first things we do after we record it and everything, is we clean off the outside of the sherd with a solvent cleaned Dremel bit. And that's just to get the gunk that people have touched it with over the years off. So that I'm fairly sure gets rid of the majority of the sunscreen, bug spray and hopefully your really quirky things like the caffeine and the nicotine. Although part of the problem is some compounds absorb within, so simply cleaning off the outer rind of the sherd actually won't get rid of everything. Particularly not plasticizers, which for whatever reason appear to be chemically very prone to absorbing deep into the pot. So nothing helps with plasticizers. But luckily most plastic products just contain plasticizers, so we can simply discount the various compounds found in the plastic and it doesn't give us false positives, so it doesn't give us fats. That's why hand creams and sunscreens are so difficult because they also include all these fats and lipids and you can usually kind of look at it and say, wow, that's a really odd ratio of lipids in this one. I bet there was hand cream. But you're kinda, you know, inferring. And then maybe if there's a biomarker from a modern scent, that'll be a definite red flag right there. So if you've got weird lipids and you've got one of these scent compounds, you know right away you've got some sort of hand cream or sunscreen going on in there. Then you basically have to try to work out which compounds in the residue you can trust and which you can't. So if it's a lipid problem, then essentially you can't trust any of the fatty acids, which is unfortunate because that's a major interpretive pathway in residues. At that point, you can't easily tell if it's primarily plant or primarily meat or fish or whatever, because the fatty acids have been skewed. And at that point you're really relying kind of on the sterol compounds, unless those look really weird too, in which case you could be in real trouble, but most of the time you can get information out of it. It's just sometimes you do lose interpretive pathways and that makes your interpretations much more difficult and certainly less specific.

Phoebe: Yeah, I see what you mean. But it's good that there are some kinds of workarounds. My last question about lipids is, how quickly are your libraries of reference lipids and fats and biomarkers building up and do you see as these reference collections get bigger, do you see lipids becoming easier to look at in the future?

Nora: I do. Most lipids are actually pretty common and are already found in sort of your standard National Institute of Science standards and technology databases. But that database doesn't include some of your really quirky compounds that maybe are commonly found in archaeological samples, but are not perhaps important to industry or food chemistry. So some of the really stranger sterols that's where my personal library has built up through time. As one does it more and as you build up kind of a personal library, it certainly becomes easier to interpret things. Even now I'll be looking at a residue and maybe I'll figure out what something is and I'll remember it was in a past residue and I couldn't identify it at the time. So then I can go back and do a stronger interpretation in hindsight than I could at the time.

Phoebe: That's really nice. Must be quite satisfying when that happens.

Nora: It is, but my most successful one involved identifying a plasticizer I hadn't known about before. So that was unfortunate.

Phoebe: Nice.

Nora: But now I know what that plasticizer looks like.

Phoebe: Yeah, it'll definitely be useful in the future, I imagine. So kind of to go back to talking about pottery. I wonder, Tim, could you tell us, what types of uses did pottery and pots have at this time? Was it only cooking and can they tell us anything about the culture as well as diet?

Tim: Well, as you can imagine, if you just go into your cabinet in your kitchen, you're gonna have vessels of all kinds of shapes and sizes and it's no different. People had to eat and store food. So you had some that were more for cooking… vessels that are more pots and others that are larger. Agricultural society from about a thousand years ago that we're looking at mass produced sort of large crops and that they can't eat all at once. So you had to have large storage vessels. You're also seeing things in some sites that may resemble plates and bowls, no different than you would, might expect to see in your cabinet, that you would eat off of. Now the question is not so much the shapes that might surprise you. When we find a broken pot sherd, first thing you think of is, was it used for cooking or eating off of, or storing? But in reality there are vessels in our own cabinets that are maybe very unique that are only used once a year for a special holiday or a ritual event or something of that nature. You see that same thing in pre-contact pottery. It may not be so much the form. It may be the decoration on it that might be a motif or design that relates to some sort of ritual. There's the famous Green Corn Ceremony, these different ceremonies about renewal and the season cycles of growing seasons that relate to some of the designs and motifs and oral traditions. So I think the reality is that people would be very familiar with some of the forms. You could pick it out of the form if anybody saw any of these what it could potentially be used for. But I think the key is not so much the primary use, but maybe secondary use of once a year kind of rituals or the design patterns on them that might be unique to that culture, to their belief systems. And sometimes when we don't know what a vessel may be used for, because it is kind of unique, we call on Nora to see if we can figure that out from the residue. And so previous studies I've worked with her has tried to look at some unique sort of craft neck bottles that have negative painting, a very unique ghost painting technique that's found in the mid-continent here in the southeast that corresponds to the same time period of these beans and sent some sherds for Nora to look at to see if it was some sort of ritual nicotine or, some sort of caffeinated drink or something that maybe inside related to this very unique vessel. And she came back and said, Nope. So that at least that was my interpretation, but I think that's part of this, of you can't just assume that something is exotic just because of its exotic form, that things get used every day for everyday uses, sometimes.

Phoebe: That's a really nice point about how residue analysis can help with those kind of things. I've got another kind of broad question, which is, do you think that your research in beans can contribute to wider conversations about heritage or sustainability in America, in the world?

Tim: That's a good question. Historically and going back to when these beans were introduced and what we think of Tennessee and Ohio River Valley, Mid-continent here, why were they adopted? And we have radiocarbon dates now in Tennessee for 13 different directly dated beans that range from about mid 14th century, up through the 16th century. So the earliest definitively is about 1350, which is kind of late compared to the oldest dated bean is 1100, so 200 years earlier up in New York, in the Great Lakes area. Why was it adopted so late? Again, I think part of this is a relationship to environmental changes that may have happened around the 13th century and the 14th century of the Little Ice Age. It was cooler and drier. And that same time we see on these sites… we find beans being introduced, at the same time as when we see palisades and fortifications going up. So there's definitely some sort of tension, be it environmental, political, social struggle and the introduction of beans might be a reaction to that, more difficult growing aspects or more tension of finding more food crops to eat in a society that didn't have beans before. Again, that's just one story to weave. Ironically, the headquarters for the Bush Brothers Bean company in the United States, which… they claim to have 80% of the common bean market and selling canned

beans and so forth, is right here in Knoxville, where the University of Tennessee is. They've provided funding, research funding for this project at the beginning as far as radiocarbon dates. And they said they were interested in this, not just the history of the beans and the heritage, but they were interested in moving forward as a company of looking at beans as a keystone for the survival of our species, of the human beings because of the protein levels in the beans could potentially allow the human species survive without having everybody eat meat all the time. And in that same vein, they didn't wanna see the types of bean varieties they use to be homogenised into just one type of bean or a couple beans. They want to maintain the heirloom taste and colours and so forth. So they had an interest as far as sustainability as a company, but also interest in the bigger picture of why beans should be important to think about as a food source for us to survive as environmental change happens right now. So I think there's a connecting point between that level of how do we survive in pre-contact times, be it Little Ice Age and conflict, political context and warfare or whatever was going on, to today of environmental change, of enlarging populations, of how do we survive and that beans might be a clue for helping us to survive as a species and move forward.

Phoebe: Yeah, that's some really nice connections between the past and the present there. Would you like to add anything, Nora?

Nora: It comes to me that one of the advantage of legumes is they do fix the nitrogen. Beans and other legume crops would allow more efficient farming. So that could also feed into why they became more popular later in the Mississippian sequence, and also ways they can help with sustainability moving forward.

Phoebe: I've got maybe two more questions before I then ask my final question. I really like asking this one, which is, what's been your favourite part of the project or most interesting result that you've had so far?

Tim: For me, the process of actually doing the experiment was something that I'd been thinking about for years and actually doing it was really fun. And the students working with me at the university, of them diving in with me and coming up with all our funny little sayings about beans as we're doing it ‘full of beans’ and whatever else, about ‘spilling the beans’. But I think one of the things that was visibly really cool for me to see was the surface residue on… after some of these sherds once we were done, of seeing the beautiful ghosting of the outlines of beans on the surface or the signature lines of the boiling episodes on the side of the sherd. That was just beautiful to see that yes, there's clearly residue on the surface, there's gotta be something inside. So that was, at least visually for me to see it happen and see what the sherds look like, after the fact, just on the surface, was beautiful for me to look at. Something coming together. Now Nora, on the other hand, that's up to her to try to make things look beautiful from what came on the inside. And we're still teasing through the interpretation of that, but I think that's one level of where I found was interesting. Another sidebar interesting thing that we didn't realise - you always find out new things, probably more questions than you do answer your questions. But since we used the Cherokee Trail of Tears Bean, which was a dark, black bean, when we're cooking that it actually dyed the water a dark, black, greyish colour. And we looked at research and there's actually looking at natural dyes and that people have used that kind of bean to make textile dyes. So we actually… you were talking about maybe doing a secondary experiment after this, using some of the water to dye some textiles and see how that works.

Phoebe: I like all the secondary things that are coming out as you do all this research. It sounds really cool. Nora, what's been your favourite thing so far?

Nora: Well, I'm still sort of just working on the analysis and doing the preliminary work on that. Unsurprisingly, I'm finding plants in there, which is not a big surprise as these things go. But I always think is interesting when you look at the sherds with their shadowing and their obvious evidence of residue, and then you can see the actual residue coming through the GCMS instrument. It's really interesting to be able to look at it and in this case match it up, because usually I don't have the luxury of looking at it and saying, yep, there's plants there, because, you know, Tim told me. So that's been really nice and it'll be interesting to see…, I wonder if the stuff that turns into black dye, if it doesn't dissolve in cold water, that could be a biomarker. We'll just have to see.

Phoebe: Oh, well I wish you all the best for your project. It sounds really interesting, as I've said a million times. I wanted to say a big thank you for such an interesting and wonderful discussion. As a final question, before we wrap up and leave our viewers with food for thought: what are your plans for the future of the project? Where will we be able to find your results once they're available? And how can the EXARC community help to make a difference in regards to some of the points that you made today? Tim, would you like to go first?

Tim: Well, the first is that once we get some level of interpretation, good, bad, or ugly, that Nora and I can come up with, that we'll be planning to publish our preliminary results here in the Journal for EXARC in the near future. And then the next step is that if we do find a method of identifying beans, I think is to apply that to real pre-contact and prehistoric pottery sherds if we can see that in the real sherd rather than in an experiment. And once we do that, then I think we can really say we have success going on. But again, that'll be a needle in the haystack maybe of finding the right sherd to use or to experiment with and getting permission to do that. So I think that's part of the next step of, we may come up with a method, but can we ground truth it with real pottery is probably the next step at that level. I've got plenty of other things I'm gonna do with beans, but I'll let Nora talk about what she thinks she wants to do next, with this or herself.

Nora: I usually sort of follow where the data takes me in these situations. So we'll see what the interpretation comes up with. But Tim is right, when you're trying to ground truth it, you're sort of dependent on finding the right pot in a lot of ways. When I developed a method for finding maize in absorbed residues, I was working from a really large set of archaeological sherds. It was 134 samples, and although there was maize in more than one, there was really only one where it was so obvious that I looked at it and was like, wow, what's going on with this one? So, you know, I always wonder if that one sample hadn't been included in the study how long would it have taken me to pick up on the method? It might have been a lot longer. I'm hoping this experimental study will make things clearer so you won't be quite so dependent on chance and archaeological samples.

Phoebe: Yeah, I've got my fingers crossed for you. So thank you very much, again, Tim and Nora for joining us today and for sharing your experience and expertise. It's been an absolute pleasure to listen to you both, and I know that I certainly learned a lot and I'm sure that our listeners did too. If you'd like to learn more about organic residue analysis, Nora also has a great new book out titled ‘An Archaeologist Guide to Organic Residue in Pottery’, which I know that I'll definitely be trying to get my hands on after such an interesting discussion. Thank you to everyone else for listening to this episode of #FinallyFriday by EXARC. If you would like to become more involved with EXARC, why not become a member? Alternatively, you can make a small PayPal donation through the website to help support EXARC in its endeavors.

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