00:00:00:00 - 00:00:41:19

Clare

Hello and welcome. I'm Clare and you're listening to Microbe Talk, the podcast by the Microbiology Society for this episode of Microbe Talk. I was joined by the wonderful Gwyn Dahlquist-Axe and Francesca Standeven to discuss their review into diet, disease and antibiotic resistance from ancient human oral microbiomes published in *Microbial Genomics*. I spoke to them about their review, how microbiology and archaeology work brilliantly together, and the complexities of working with ancient human material.

00:00:41:21 - 00:01:06:12

Clare

Thank you so much for joining me today. I'm really excited to do a podcast about why archaeology is an interest of mine, and I'm really excited to have you both on here. Obviously, talk about your paper published in Microbial Genomics, a V titled Inspiring Diet Disease and Antibiotic Resistance from Ancient Human Oral Microbiomes, and that's published in Microbial Genomics.

00:01:06:18 - 00:01:12:04

Clare

Well, two of your guests, are you able to introduce yourself?

00:01:12:06 - 00:01:35:16

Francesca

Yeah. And hi, I'm Francesca. My background's a bit of a mix, really. So I did my B.A. in classical civilization. So ancient languages and literature. Then I didn't need historical archiving. And after that I went on to do a masters in bio archaeology, which led me here. And now I'm a third year PhD student at the University of Bradford researching ancient oral microbiomes.

00:01:35:18 - 00:01:37:21

Clare

Have perfect English.

00:01:37:23 - 00:02:06:00

Gwyn

So hi, I'm Gwen and I've got kind of a similar bat related background, so I am an archaeologist. First and foremost as well. I did an undergraduate degree in anthropology and I did a master's in

archaeological sciences, and then I worked as a field archaeologist in Canada, and then I'm here now as a third year peer, actually student at the University of Bradford, also studying ancient human oral microbiomes.

00:02:06:02 - 00:02:17:08

Clare

Amazing, Amazing. I think we have to start from the beginning. I think it's important to discover what is bio archaeology, what is archaeological science.

00:02:17:10 - 00:02:39:15

Gwyn

I'm yeah, as far as I know, definition of by archaeology is I think in different areas it has different definitions. So I'm from Canada and so in North America, if you say bio archaeology, it's strictly means and the study of human remains. I did my amity and archaeological sciences, which incorporates bio archaeology but has a bit of a broader scope to it.

00:02:39:17 - 00:03:07:19

Gwyn

Archaeological sciences have a really broad spectrum. A lot of it is to look at scientific analysis so the different methods we can analyse the past. So some of those are by archaeology, looking at human remains, geophysics, looking at Earth's features and landscapes. See what we can see below the ground and visualization of things taking 3D models and mapping things.

00:03:08:22 - 00:03:20:05

Gwyn

and then there's that chemical analysis as well. So trying to determine what the chemical makeup of something was that maybe someone was eating in the past.

00:03:20:07 - 00:03:49:23

Clare

It's like purely by definition it is just this multidisciplinary kind of area of research. And I think that's what's the most exciting thing about it. If you're coming from a historical archaeological perspective, you probably wouldn't expect this kind of research to be published in microbial time, like an out and about microbiology journal on that. No. Why do you think by archaeology and microbiology, how do they work together in the context of kind of archaeological research?

00:03:49:23 - 00:03:52:15

Clare

Where does what is microbiology come in?

00:03:52:17 - 00:04:23:08

Francesca

And so those two subjects are really interesting to put together. And it's not even just those subjects. It it's also and we we were sort of thrown into that the deep end with bioinformatics as well. And so we have a really interesting team. We have bioinformatics, microbiology and bio archaeology and a lot of computational science. And the combination of those things I think produces really, really, really good work.

00:04:23:08 - 00:04:59:10

Francesca

They complement each other massively. The microbiology likes the context of archaeology, and archaeology likes the context of microbiology, and it can produce some really interesting stuff. Like as archaeologist, we like to know about biological sex and gender studies and stuff like that in the past. And microbiology helps us understand that more because we can use not Stephen DNA but protein analysis now to understand biological sex so that all those fields really do complement each other in that sense.

00:04:59:12 - 00:05:13:01

Clare

Yeah, perfect. I love that. So I suppose then let's go on to your your review. Could you just briefly introduce your article, what it's about potentially about main conclusions and findings.

00:05:13:03 - 00:05:44:01

Francesca

And so our review of say explores like key historical events throughout time. So this is the archaeology. This is like our favourite thing to do and we try to understand how these events changed our microbiology. So, for example, how bacterial ancestors defended themselves or different abundance levels of the pathogens And these things all give us indications on what types of diets and diseases historically humans had.

00:05:44:03 - 00:06:08:14

Francesca

And there's a lot of ways to look at ancient microbiomes. So like ancient skin or goat microbiomes, but since organs like skin don't often survive unless we come across mummified individuals and dental calculus, However, it's very abundant in the archaeological record, and it's that sort of sticky stuff. You get any teeth if you don't brush and that hardens and acts like a time capsule.

00:06:08:14 - 00:06:36:22

Francesca

The DNA that belongs to all kinds of microorganisms like mainly bacterial and in dental calculus. So because of this, our review looks at what biological information, dental calculus has to offer us on panels of individuals and how they were affected by their own ways of life. So like the slow transition to farming or when we decided to eat more certain foods like sugar and carbohydrates.

00:06:36:22 - 00:06:44:02

Francesca

So pollution and the creation of new medicines as well. So that's what our review is like exploring.

00:06:44:04 - 00:06:52:11

Clare

And you looked at this mostly kind of within the context of anti-microbial resistance. What made you kind of go down that avenue?

00:06:52:13 - 00:07:19:15

Francesca

So I ama, I find is a very interesting topic anyway. And as an archaeologist who was very quickly introduced to hard science, I didn't quite understand how AMA was ancient. I thought it was like a very much a modern thing. It's like, it's been discovered in ancient caves. But then after researching the topic, it became clear that ancient AMA is actually very normal and not surprising at all.

00:07:19:17 - 00:07:46:19

Francesca

Like micro-organisms have always fought each other. And it's interesting to see that preservation of that wall in the natural environments of permafrost and microbiomes of dental calculus. And we can learn a lot. We can take the pathogen and investigate how that pathogen

reacted under stress in the past and if we have an idea, we can predict how it may act face with new drugs, for example, also antibiotic resistance genes.

00:07:46:19 - 00:08:10:22

Francesca

So these genes belonging to bacteria that allow them to fight off drugs or microorganisms to kill them can even perhaps give us a sense of what historical humans were eating. So if they if they have a lot of resistance genes belonging to ancient soil, bacteria that we don't see today, this could open up a lot of discussion on how different microbiomes were influenced by diet back then.

00:08:10:24 - 00:08:40:24

Francesca

And we can also see whether like historical events before Human made antibiotics had an impact on the level of antibiotic resistance in our oral cavities. So for example, metal resistance genes, they often come with antibiotic resistance genes. If we see a lot of metal and antibiotic resistance genes in ancient oral microbiomes from the Industrial Revolution, for example, we might want to think about how pollution today is affecting our democracy.

00:08:41:00 - 00:08:44:21

Francesca

There's a lot that can be explored in archaeology. Regarding AMR.

00:08:44:23 - 00:08:50:07

Clare

Yeah, I think specifically the one about metal pollution and or what?

00:08:50:09 - 00:08:57:00

Francesca

Yeah, it's cool. Yeah. Yeah. I mean, it might, it might not be, it might not be anything, but it's definitely worth investigating.

00:08:57:00 - 00:09:15:03

Clare

So yeah, for sure. I'm just to tie back slightly, you mentioned kind of ancient oral microbiomes, then you kind of talking about the Industrial Revolution as well when you're considering ancient dental calculus samples. What is that referring to? What does ancient mean again?

00:09:15:05 - 00:09:26:22

Francesca

Is it because because I've heard loads of different opinions on this. I know what you've heard, but I've heard in the last hundred years is what's considered ancient. But yeah.

00:09:26:22 - 00:09:58:06

Gwyn

So there's I'm, I think also depending on what country you're in, there's also different definitions for it. So like in England there's a certain definition of what's considered archaeological and then what's considered and just historic or modern kind of it's completely different. But I think in the context of this review, at least, we're considering ancient as anything over a hundred years ago to thinking about the industrial evolution in that ancient context as well.

00:09:58:08 - 00:10:22:21

Clare

Yeah. Okay, perfect. So you mentioned about AMA being a really nice kind of lens to look through the history and the archaeology of human or microbiomes. You're gathering this information. It obviously is all together in this river. How do you think or how would you hope to think that that would inform today's microbiologists and the AMA crisis?

00:10:22:23 - 00:11:01:14

Francesca

Yeah, So I like I mentioned before about understanding how microorganisms in the past reacted to certain stresses. Yeah. So all the so example or the microorganisms trying to kill them or on natural drugs produced in the environment if we understand that behaviours that past behaviours when we're trying to make new drugs as an alternative therapy the infection we could avoid making the same mistakes.

00:11:01:16 - 00:11:28:15

Francesca

Perhaps we can learn that certain pathogen is likely to that, you know, confer resistance to something if we see that it did in the past microorganisms in in the past in clean models, for

example, sources that aren't affected by modern day antibiotics and learning about how they reacted with honey, for example, is make it an indication of how they will do today.

00:11:28:17 - 00:12:04:07

Francesca

So it's so predictive value for microbiologists and also microbial evolution as well is would benefit a lot from looking at a microorganism in the past because and that confer resistance genes because then we can build pathologies at scale and understand resistance pathways and and how the microbiome changes over time and how we became more resistant to certain things.

00:12:04:07 - 00:12:21:12

Francesca

And if resistance is actually an innate feature of the microbiome of the oral microbiome, because if it is, then we need to start looking more at the or microbiome as like a like a sort of breeding ground and spread as AMR in the public today.

00:12:21:14 - 00:12:46:07

Clare

Yeah, it's like, it's like a perfect snapshot, isn't it? It's like a slice in time of like being able to investigate like a very particular point. Yeah. So interesting. So this review focuses around investigating dental calculus and using like DNA methods. Could you give me like a brief introduction about how that works and why? It's kind of quite complicated.

00:12:46:09 - 00:13:28:01

Gwyn

Yeah, I can talk about that for sure. So Francesca mentioned earlier, dental calculus is really common in the archeological record, especially in the more recent past. It's very rare to find human remains that don't have dental calculus. So it's a very, very rich resource. It's something that we can very easily have access to. So the way that we've studying it is quite simply you pick it off of a tooth, which again kind of solves another little problem with looking at DNA analysis because you're not destroying any of the human remains themselves because dental plaque is not a human tissue, it's an amalgamation of coastline bacteria.

00:13:28:01 - 00:13:58:19

Gwyn

So you're not having to destroy any human remains, which can be beneficial for a lot of cultures. Where that is is not acceptable to destroy human remains. So being able to look at DNA from that, that perspective can be really helpful. So when we sample dental calculus, we're taking it right off the tooth and then it goes through a lot of the same procedures as other ancient DNA analysis.

00:13:58:19 - 00:14:19:20

Gwyn

So when it goes to the lab, you're having to extract your DNA in the same way it gives sequenced in the same and very similar way. But the issue, I think with dental calculus comes down to a lot of contamination and not as easily being able to pick out what is contamination and what do we actually want to study.

00:14:19:22 - 00:14:42:10

Gwyn

So with human, human DNA, it's very easy. You map, it's the human genome and anything that isn't human you can just throw away because we want to look at the human DNA, but with bacteria, we want to study the bacteria. So how can we pick out what's low contamination, What is environmental contamination, what's modern, what's ancient? All of those things.

00:14:42:12 - 00:15:13:15

Gwyn

There's a lot of really good methods for that, both physical and computational. And so the bleaching and the UV lights and those kinds of things that are the physical methods of doing it, as well as the protective equipment that's used. Something that Francesc and I have been looking at is the computational methods of, of decontamination. And we've been through quite a few processes trying to figure that out, because one of the troubling issues we've come across is ancient environmental contamination.

00:15:13:17 - 00:15:37:14

Gwyn

And usually a environmental control sample is included in this dataset. So if you have a collection of dental calculus, often you will have a little bit of a bone sample or soil sample or something like that that keeps a record of what happened in that burial environment but doesn't have the oral inclusions. So you can separate those two out once you get to computational analysis.

00:15:37:16 - 00:16:06:06

Gwyn

But archaeology isn't quite as simple as that. And a lot of the times we're looking at collections that never intended to look at oral microbiomes or never intended to look at ancient DNA or have been in someone's cupboard for the last ten years and you don't know where it came from. So in those cases, it's a little more complicated to separate out the environmental contamination, especially if it's ancient contamination.

00:16:06:07 - 00:16:12:04

Gwyn

We can't use the simpler computational methods that are very successful currently.

00:16:12:06 - 00:16:21:06

Clare

I think that's what makes archaeology really fun, is that it is really annoying that there's all of this other stuff going on. It just makes it a little bit more. There's a bit more of a chase.

00:16:21:12 - 00:16:28:12

Gwyn

Yeah, it's never just A to B, it's the whole pathways wiggled in between that.

00:16:28:14 - 00:16:35:23

Clare

Could you talk a little bit as well about degradation? How do how do you deal with that damage of the genes?

00:16:36:04 - 00:17:15:04

Francesca

And so damage is actually we actually like damage because damage allows us to authenticate our DNA and actually say that this is actually ancient. It actually really helps if you finding it hard to decontaminate your samples. You can also damage, authenticate it and say, okay, this is this looks agent. And it doesn't mean that if you don't have a if you lack an environmental sample and you do damage authentication, it can still be ancient, but it doesn't tell you if the keys are environmental, ancient contaminant or not, they don't make sense.

00:17:15:06 - 00:17:41:04

Francesca

And so we do like damage and we don't like damage. That damage can cause a lot of problems, like if we want to assemble whole genomes. So we start off with these little tiny genes and we want to put them all together and make a big genome. That damage can cause problems in the software trying to identify those genomes.

00:17:41:09 - 00:17:44:12

Francesca

Yeah, so the simplest way I can put it. Yeah.

00:17:44:14 - 00:17:50:15

Clare

And that is whether that is are they not there because of the damage or are they not there because they never existed?

00:17:50:17 - 00:18:17:14

Francesca

So, for example, you so you have a damaged genome and the only way we can identify that genome is by matching it up with a modern genome of the same species like of its ancestor. And we're doing with mapping it to a modern genome and they might not match because the ancestors just too damaged. So we have trouble reading that.

00:18:17:14 - 00:18:23:06

Francesca

So damage just called problems and in identifying species but yet so that's that's the issue with some it.

00:18:23:08 - 00:18:31:20

Clare

And this phase as well is that the added complexity or obviously the modern sample is a modern sample and it's evolved. Yes. Yeah.

00:18:31:22 - 00:18:57:15

Francesca

Yeah, exactly. Yeah. So we have and like the chances that we get loads of species that are extinct and obviously those extinct species don't exist in our databases to match it with. So it will match us to the most recent ancestor. And even then we're not really sure how related they are. So it's again, yeah, it's very complicated when it comes to ancient DNA.

00:18:57:20 - 00:19:18:24

Clare

Yeah. And I suppose like when it then comes to the context of oral microbiomes and using this information to infer diet, health impacts of environment and that kind of stuff you're looking in and understand that there are some examples in the review of like looking at and understanding specific microbes in the mouth and what that might have meant.

00:19:19:01 - 00:19:21:15

Clare

That must be quite frustrating. But I guess.

00:19:21:21 - 00:19:45:01

Francesca

Yeah, it's very difficult with, with age and stuff because we have to set thresholds. So we don't want the threshold too high because we won't get anything that ancient. We don't want them to low because it could be anything that we get. So it's about finding that's off balance, but there's no like guidelines or anything out there that the ancient threshold, not yet at least.

00:19:45:01 - 00:19:52:06

Francesca

So that's something that definitely needs to be discussed in the bio archaeology computational science community.

00:19:52:08 - 00:20:10:17

Clare

Yeah, so neat. I love it. And so I want to I always like asking this question and what is the most, like, interesting or surprising thing that you came across while setting the research for this review that just shocked you.

00:20:10:19 - 00:20:15:23

Francesca

To think about this So much. So much. Yeah. I need to think for a minute.

00:20:15:23 - 00:20:50:07

Gwyn

I was going to ask think for a second. Okay. You've got like a little, little something. So I think we went into it with our our understand thing based on modern studies because that's kind of the basis of a lot of ancient microbial research is we kind of basing it on these modern models. And from what we know about modern bacteria and their behaviour, we had this idea that, you know, you change your diet and you're going to get a lot of different things happening in your mouth.

00:20:50:07 - 00:21:33:02

Gwyn

You start eating a lot of sugar and stop brushing your teeth. You're going to get cavities or a lot of plaque and that kind of thing. So trying to transplant that into all of ancient human history kind of I think it was a lot more and it's a lot more difficult to see those changes, which again, not a huge surprise, but it was and I think interesting to see that play out like we really wanted to show something where, you know, everyone starts eating sugar and then there's a huge change in the composition or abundance patterns of pathogenic bacteria or something in the order of poverty.

00:21:33:04 - 00:21:58:07

Gwyn

And but so far, there aren't any studies that show that. So that was, I think for me, the biggest question that remains. It was a big surprise that we don't have that yet. And it's why don't we have it? Is it because it just didn't happen in the past? Is it because the way that those bacteria are preserved, there's some kind of preservation bias and we're not seeing them in the archaeological record?

00:21:58:09 - 00:22:15:20

Gwyn

Or is it just because the studies haven't been done yet? There's a lot less research done, obviously on ancient bacteria than there is on water. So there's so much we don't know about ancient bacteria where we're kind of trying to guess what's going on based on the modern stuff.

00:22:15:22 - 00:22:26:00

Clare

Yeah, I can see why that was. I suppose shocking was frustrating, I suppose at the same time. Francesca, have you thought of anything honestly?

00:22:26:00 - 00:23:07:09

Francesca

Like, obviously everything we come across every day is always a bit like, Wow, I didn't know that. I wasn't expecting that. But I think for me, because as I mentioned before, I came in as an archaeologist and very humanities based and it still shocks me how clever the methods are, like the lab methods and the computational science is for analysing the ancient DNA and although the ancient DNA is very delicate and damaged, it's still not over thousands and thousands of years over 10,000 years.

00:23:07:09 - 00:23:22:23

Francesca

That's incredibly resilient. I think that it's still here, that we can still take something from it. So I think that's I still find that really crazy and but also very promising for the ancient DNA studies.

00:23:23:00 - 00:23:45:05

Clare

Amazing. Amazing. And that's like quite often I have, you know, microbiologists and scientists obviously on this podcast and they talk about the like thrill of knowing something that someone else doesn't know, being the first to discover something and how great that feels. You kind of get the extra added fun of it being ancient. You're finding out about past peoples, and I can't imagine how great that must be.

00:23:45:06 - 00:23:46:19

Clare

But wow, look at this.

00:23:46:19 - 00:24:23:10

Gwyn

You think? Yeah. I think my favourite thing about being an archaeologist, but then now being whatever word you can think of to describe whatever the ancient microbiology maybe is, every now and then will will be able to pick out. We have, you know, one individual a sample from their mouth. And we see one specific thing that kind of gives us a glimpse into what they were doing, like of this person smoked a lot, kind of, wow, you can just picture them sitting by their fireplace, smoking their pipe, maybe snacking on something.

00:24:23:10 - 00:24:47:06

Gwyn

And it's that's for me, the coolest thing about archaeology and then bringing in this microbiology aspect is we're now seeing things like, you know, this person must have been in pain for a large part of their life. What would that what would they have been experience? How would they be feeling that? How would their relationships with their family been and how would they have been supported through having that that kind of pain?

00:24:47:06 - 00:24:51:15

Gwyn

And then stuff like that is really interesting, I guess.

00:24:51:17 - 00:25:04:14

Clare

Yeah, definitely. I'm very jealous. Very jealous. It's so interesting. We are just all struggling. So many different like nuances and different subjects and this. That's really cool. I apologize. I do have one more question. I want.

00:25:04:16 - 00:25:06:01

Francesca

One.

00:25:06:03 - 00:25:16:09

Clare

And what motivated you to kind of attack this review? Like what? What what was it that kind of brought it to your mind and motivates you to do it?

00:25:16:11 - 00:25:50:08

Gwyn

I'm I think from coming from an archaeological perspective and being introduced into like hard and fast microbiology, there's obviously it's a growing field. There are quite a few people out there researching each natural microbiomes and each microbiomes in general, but it's still not the robust and flourishing discipline that a lot of these other fields of research have. So I think to

have a more succinct place to look at what do we currently know about ancient oral microbiomes?

00:25:50:08 - 00:26:25:17

Gwyn

How do we know it? What don't we know? Which I think is one of the bigger questions and how can we find that out? I think we wanted to have that nice little summary of where the field of ancient oral microbiome are as of now. Partially, I think for our own peace of mind, like coming into this PHC, knowing absolutely nothing about them, and then in the last two and a half years, getting to a place where we can actually kind of have a bit of a summary, be able to write a summary about what's going on and hopefully that will help other scientists both just out of interest.

00:26:25:17 - 00:26:40:22

Gwyn

Like if more people would be interested in it, then then maybe more research will happen. And then the people who are already doing the research to get them looking at the little questions we still have and thinking, you know, where the little gaps in research that we can all start working towards together.

00:26:40:24 - 00:26:59:22

Clare

I mean, that's a lovely answer. I love that. Thank you so much. It was great to be able to talk about like archaeological sites, bio archaeology, all of that sort of stuff, whatever you want to call it, all of this with you guys is really, really interesting. And is there anything else you particularly wanted to add or get across?

00:27:00:03 - 00:27:01:05

Gwyn

I don't think so.

00:27:01:07 - 00:27:02:01

Clare

I think so.

00:27:02:01 - 00:27:07:03

Francesca

The let it all out therapy session.

00:27:07:05 - 00:27:30:10

Clare

Yeah. Yeah. So thank you so much. It's been it's been such a pleasure. Thank you.

Thanks again to Gwyn and Francesca for that interesting discussion on the brilliant field of archaeological science. If you'd like to read their paper or keep up with them and their research, the link to the paper and their socials are in the description.

00:27:30:12 - 00:27:44:18

Clare

Thank you for listening to Microbe Talk, If you enjoyed this episode please share, like or leave a comment wherever you're listening.