Briana Pobiner:
Hello, and welcome to today's program, Ancient Pyrotechnology; the Role of Fire in Human Evolution, which is part of our ongoing Hot Topic, Human Origins Today topic series. My name is Briana Pobiner and I'm a paleoanthropologist and educator at the Smithsonian's National Museum of Natural History. Whether this is your first time joining us or you've attended before, we're so glad to have you here.

Briana Pobiner:
Before we get started a few housekeeping notes. This discussion offers closed captioning. You can turn them on or off via the CC button, which should be located at the bottom of the Zoom interface. As you have questions, please go ahead and submit them to the Q&A box, which is at the top or bottom of your screen so we can sort through as many as possible the Q&A really flies by. The Q&A box is also where we'll share any relevant links during the program, so keep an eye out there.

Briana Pobiner:
We'll start with an opening presentation by our speaker, Dr. Ellery Frahm, and then I'll join him here to take your questions. And just before we start, I'd like to say that it's a special day today for the Hall of Human Origins team. Today is the 12th anniversary of the opening of the Hall of Human Origins. You can see a view of part of our exhibit behind me, although I am Zooming in from my home in Maryland today.

Briana Pobiner:
Now I'd like to go ahead and introduce our speaker. Dr. Ellery Frahm is an anthropological archeologist with a scientific bent, using materials characterization in the field and lab to study otherwise unobservable behaviors in the past. Currently, he's a research scientist and lecturer at Yale where he is the director of the Yale initiative for the study of ancient pyrotechnology. He has conducted and published research on four continents; Asia, Europe, Africa, and north America, spanning almost half a million years of human history.

Briana Pobiner:
Much of his research focuses on Southwest Asia including the near east and south Caucasus. A unifying theme of his work is elucidating how different human groups made use of natural resources distributed across the landscape, had they responded to challenges within their environments and had the resulting behaviors influenced connectivity and in turn opportunities for the spread of technological innovations and social changes. Thank you so much Ellery, and I'm looking forward to your presentation.

Dr. Ellery Frahm:
Oh, thank you so much, Brianna. Thank you for the invitation and thank you so much for the opportunity to speak with everyone today. And I did want to recognize the anniversary of the Hall of Human Origins today with the background here of one of the life size bronze statues that are in the hall. This one being a human ancestor Homo heidelbergensis holding out a piece of cooked meat to share with the visitors. And we'll come back to this at the end of the talk.

Dr. Ellery Frahm:
Here at Yale, I am the director for the Yale initiative for the study of ancient pyrotechnology. That is a bit of a mouthful. So for short, we call it Y-Pyro. I like this abbreviation because it's also a question, Y-Pyro? And the answer to that question is that for most of human history, for millions of years of human history, technology and innovations can be framed in terms of greater and greater control of fire, achieving higher temperatures for longer periods of time, to increasingly alter materials and create new ones. This holds true up until basically the 20th century when we start getting artificial materials like the first polymer bases like bakelite here. And now that we're doing 3D printing and nanotechnology, now it

involves more structure and scale, but for most of human history, it's been about heat and temperatures.

Dr. Ellery Frahm:
So although for decades, humans were kind of conceptualized as being special in terms of their ability to make and use tools, we know that's not really the case anymore, other animals make and use tools. But our genus at least, the genus homo, is unique in its ability to create and use fire. And I think we should hope though, that it stays that way, at least for the foreseeable future.

Dr. Ellery Frahm:
Now, one of the quotes that I like best about that really summarizes why I study both fire and stone tools is summarized here from this article in Current Anthropology. And that it points out that stone tools and fire are two of our most important milestones in human evolution. These are milestones that are outside the body, so they are adaptations to the environment and to the world that don't involve something with our own bodies. It's not an opposable thumb, it's not the sizes of our brain specifically, they are technologies. And so throughout this talk, even though fire is the main theme, you will see these two technologies recurring together because they are extremely linked and it makes sense to study them together for reasons that you will see.

Dr. Ellery Frahm:
Before we get too far, I wanted to place us in time. And here we are with millions of years across the bottom and different human ancestors scattered through time periods. I do want to clarify that when I am talking about humans, for me, that means members of the genus homo. If I'm talking about modern humans, us homo sapiens, I will say modern humans. But everyone else to me is human. Neanderthals are people. Heidelbergensis, like you saw on the title slide, people. So just a point in clarifying when I'm speaking today.

Dr. Ellery Frahm:
Now we can put up quite easily milestones in stone tool technology here. And you see here they're labeled in their mode numbers, which is a more recent terminology. Don't worry about what those modes are, just that they are numbered in terms of important milestones in stone tools. And you can even see when I put them on the timeline here, that they sometimes seem to line up with the emergence of certain human species in the past. So Mode 0 predates are genus. Mode 1 kind of seems to line up with it time wise. Mode 2 with Homo erectus. Mode 3 kind of seems to line up with Neanderthals. All of those can be discussed in depth later and how relevant they are, or how real, but they're at least there to test hypotheses about.

Dr. Ellery Frahm:
Before we move on to placing fire on this timeline, I do want to highlight just mode 3 that's going to come up in the talk. So just remember mode 3 shows up at about 300,000 years ago. So let's put fire on here. It's a lot of question marks. It is not an exaggeration to say that everything about the timing of fire is debated. Some people based on their hypotheses would have to put at least the use of fire by human ancestors, millions of years ago. Some people will put it that only modern humans us were able to create fire on demand. So it's anything and everything in between has been argued in the past. And there's a reason that there's very specific lines on there, timeframes for stone tools and all these question marks for fire.

Dr. Ellery Frahm:
And so a former advisor of mine has a saying he used to say, "Love is fleeting, but stone tools are forever." And in fact, this is hanging in my office. And it's just kind of a tongue-in-cheek way of saying that the preservation of stone tools is very good. A chopper 2 million years ago, it'll weather, but you can identify it 2

million years later today. So the preservation, archeologically, of stone tools is very good. And that's what makes them great for study.

Dr. Ellery Frahm:
For fire, at least traditionally, it's much more ephemeral. I don't know about you, but when I look at this sort of image, I can just imagine doing a big puff of air on it, or the wind coming by, and embers go flying everywhere, ashes is spreading. It's much more ephemeral, at least in terms of how fire has traditionally been recognized in the past. And we are developing new ways to identify heat and fire in the past. And so I've got a series of three questions that the talk is framed around before the official Q&A, but I thought these would be good ones to address in order here. And the first one is linked to this problem of fire evidence, at least in traditional senses being rather ephemeral.

Dr. Ellery Frahm:
So the first question, could the Neanderthals create fire? I don't think it's any big surprise to anyone that Neanderthals have had kind of a poor image, as Geico has also helped us realize as well. But these are actual reconstructions you could see in the Field Museum, in Chicago, of Neanderthals in the 1930s and by souvenir postcards of them. You compare that to, again, the life size bronze-age statues in the Smithsonian Hall of Human Origins, we get a much more sympathetic view of Neanderthals as being much closer to us than was previously thought.

Dr. Ellery Frahm:
And this extends to fire too. So we have here in 1950s, paleo artist Burian, with this particular piece called Neanderthal fire. And it's obviously very kind of hairy brutish Neanderthals, but they're also reconstructed in a way that, thanks to the rainbow really implies, that they are making use of the forest fires, not making the fire themselves. And so this is still a topic of investigation, of debate.

Dr. Ellery Frahm:
And so a few years ago, this paper by Dibble and colleagues came out and made the argument that good evidence for Neanderthal fire use is really absent during ice ages, during cold glacial climate cycles. And to them, and I'll step you through this, that suggested to them that Neanderthals did not create fire on demand. They were users of natural fire on the landscape like lightning strikes for forest fires. First it's worth quickly investigating or addressing, what does that good evidence mean?

Dr. Ellery Frahm:
Traditionally, we're talking about microscopic examinations of cave sediments. So in this case, this is a thin slice of sediments from a cave in France. And it highlights microscopically some bits of burnt bone that would've been in like a campfire within the cave. So it was this kind of traditional evidence for fire use that Dibble and colleagues suggested was most common during warm periods between glaciers called interglacials, and really absent during cold periods. And so to them that suggested that during these warm periods, there was also greater precipitation and more lightning strikes and therefore Neanderthals were only using natural fire on the land escape from these greater periods with lightning strikes.

Dr. Ellery Frahm:
Now, this is a global trend, and we know from climate modeling today, because people are very interested in such things, that when the world gets warmer on a global scale, it doesn't necessarily mean that precipitation is greater everywhere. In some places it's going to be drier, in some places it's going to be wetter. Some places lightning might increase, some places lightning might decrease. So it's not necessarily a great proxy. So one of the sites where I work called Lusakert cave in Armenia, my colleagues led by Alex Brittingham, came up with a more geochemical way

to look for fire traces that might be able to address this question more sophisticatedly.

Dr. Ellery Frahm:
And the basic idea that, that research followed, was that a lot of different hydrocarbons combustion products are put out by a fire. And some of these combustion products fall into this category, what's called polycyclic aromatic hydrocarbons, which again is a mouthful, so PAHs for short. These are just these rings of organic molecules for our purposes here. The light ones are light simply because they have fewer rings and the heavier ones are heavy because they have more rings. And just due to gravity, lighter ones can go up and be suspended in the atmosphere over great distances and heavier ones will fall down close to a combustion source and not travel more than a few feet.

Dr. Ellery Frahm:
So what this suggested is that these two classes, the light and the heavy ones could be used as proxies for forest fires versus local fires respectively. Now, let me just put that another way here. If there is a cave site with camp fires, there should be more heavy PAH in the sediments. If there is forest fires on the landscape, light PAHs could drift into the cave too. And then the idea is that today we can come along, archeologists can sample the cave sediments and look at that ratio between light and heavy ones to see does the frequency of local campfires match the frequency of forest fires on the landscape.

Dr. Ellery Frahm:
So that's what the team did. That's Alex there in the red shirt and some of my other colleagues at the cave, which is about 40,000-60,000 years ago in terms of its habitation. And then here is a photograph of one of the stratographic sections, the layering, in that cave. So the top one's a photograph and the bottom one is a cartoon. All of these numbered layers of sediments within the cave were sampled for those hydrocarbons. In addition, the blue dots are bits of broken bone and all those red dots are stone tools. And I'll get back to those in a moment.

Dr. Ellery Frahm:
So there's also the traditional indicators of fire there as well. So for example, looking through a microscope and seeing burnt bone, it's there. So if the hypothesis of Dibble and colleagues was correct, there should be a direct correlation between the number of campfires at the site and the number of forest fire on the landscape. It should be a linear straight line on a plot, and here's the actual data, it's not correlated at all. So we have a much different picture, not of Neanderthals as opportunistic fire users, but of being able to create fire on demand, a much more sophisticated picture of Neanderthal use.

Dr. Ellery Frahm:
Now, this is also interesting because, and there's other aspects to this because as Brianna mentioned in my introduction, I'm interested in how innovation spread. So I'm interested in how fire could go from one group to another along with other technological innovations. And this is where the stone tools come in handy because in this part of Armenia, the tens of thousands of stone tools that are in that cave site are all made out of obsidian volcanic glass. So at this site in the middle of Armenia, I can go and chemically match all of those stone tools to different volcanoes across the landscape and get an idea where the inhabitants of that site tended to move and spend their time. And then I've done this at other sites. And what happens is I'm able to start building up a network of where different groups could have interacted on the landscape to spread technology advances. Be it stone tool technology, or fire technology, or any other sorts of cultural advances that are emerging at this time. So this leads to the second question, how did fire spread as an innovation?

Dr. Ellery Frahm:
And the traditional view is that fire would've been invented in one spot and spread everywhere. This is the same traditional view of a lot of stone tool innovations, is that somewhere in the world, there was one origin that led to this innovation. And then from there, it was transmitted either by people moving or culturally all throughout the world. And this is essentially the argument that was laid out in a paper last year by McDonald and colleagues that in their view, the good evidence for fire use really only emerged worldwide and was convincing after about 400,000 to 300,000 years ago. That this, they argued, was one of, if not, the first instances of cultural diffusion, so technology spreading from person to person and group to group across the landscape quite quickly. And they directly linked it to the emergence and spread of that mode 3 technology that I told you to keep in mind.

Dr. Ellery Frahm:
So it's worth mentioning what that advance mode 3 technology is, if we're going to liken fire use to its spread. So you see here, the difference between what's called mode 2 and mode 3. They have names like Acheulean and Levallois, but we don't need to worry about those right now. And basically mode 2 was shaping a piece of stone by knocking flakes off of it. And when you are done getting the shape you want, and you have your tool, you stop shaping that piece of stone. And then you have, for example, a buy face, a hand axe like this pictured here. That was the height of human lithic technology for about a million and a half years, and then came this mode 3. Where the difference is, you shape a piece of stone, and then the last step is you take a flake off of it, and that becomes the tool you want. So that was the innovation.

Dr. Ellery Frahm:
And if we kind of sketch it out by step, I think it becomes a little clearer, and this is a bit simplified. But it becomes clear that it is the next step in mode 2 technology. It's not something entirely different, it's an evolution of it to the next stage. The kind of thing that could come about through experimentation and doesn't necessarily need to be invented by one person or group and spread throughout the world.

Dr. Ellery Frahm:
And that's what was argued at another site where my colleagues and I work called Nor Geghi, not too far from Lusakert, this is a site that's 400,000 to about 320,000 years old. And it documents the local rise of mode 3 technology alongside mode 2. And so along with that early date of mode 3 appearing, other sites were plotted up where that mode 3 is present and also where it's absent. So here, this represents 340,000 years ago. This is an interglacial, so warm period between ice ages. And so the green checks are where there's the mode 3 lithics and the red Xes are rather or not. And you see, it's already patchy. There's not a diffusion pattern. And as we move through time, again, to other of these earliest sites where mode 3 emerges, this is 300,000 years ago. This is 240,000 years ago. You see it's patchy, it's not radiation from one central discovery. And that was our argument in that paper in 2014, is that mode 3 was patchy emergence. It's probably independent innovations or emerging out of mode 2 as kind of a logical extension of it. And that humans are technologically precocious. We experiment a lot, it is not infathomable that this development could be reached in multiple places throughout the world.

Dr. Ellery Frahm:
And then the other part of that McDonald paper that suggested cultural diffusion from one point, is that they're working with a highly European skewed dataset. And outside of the Middle East, they had only one site in Asia. And that is Zhoukoudian, which is more commonly known as Peking Man Site, just outside of Beijing. And they said, this fits the pattern. That the age estimates from Zhoukoudian vary between, they say 50,000 to 250,000 years ago. It's the same time

period as they're arguing there's fire in Europe. It fits the pattern, end of story!

Dr. Ellery Frahm:
Again, the challenge with that is that there's a lot more recent dating techniques, that those dates they cited come from the seventies, eighties, nineties. There's been much more recent better dating, most of it done by Guanjun Shen. In fact, this paper here on the top was done with a few of my former university of Minnesota colleagues. And here I've got those newer dates on a stratographic section for Zhoukoudian Locality One. And you see that instead of saying the site is 250 to 400 or 500,000 years old, it's more like 400,000 to almost 800,000 years old. It's much older than people were thinking in the eighties and nineties. And this has led people, for example, Attwell, et al, who also looked at fire this same period to argue that Zhoukoudian really is the best example so far for evidence of independent innovation of fire use. And when you do something similar to what we did, we're mapping the distribution of early mode 3 lithic technology. Again, you see dates that are kind of all over the place all around the world.

Dr. Ellery Frahm:
I'd argue again, this is a really patchy distribution that does not favor some sort of cultural diffusion throughout the Eastern hemisphere. So I think it's the case that locally, whether it's stone tools or whether it's fire technology, these innovations were spread by learning. Parents teaching their children, groups teaching other groups. But I also think that we have reasonable evidence, both from the stone tool side and the fire side of independent innovation, going back to that argument that humans are technologically precocious.

Dr. Ellery Frahm:
But this point you might be wondering, "Okay, I get the one step almost, that it takes to go from mode 2 to mode 3 stone tools. There is one difference just popping off that flake to become a tool. How do you get fire as essentially kind of being precocious, messing around, discovering it independently? How does that happen?" And so that ties into the less of the three questions. And my talk here is how did early humans make fire? And I think the challenges is that if you look in an old book, you'll see early humans making fire by rubbing sticks together. If you were in the boy or girl Scouts, you might have learned you rubbed sticks together, that's how humans start fire. If you watch movies like the Quest for Fire, you're going to see early humans rubbing sticks together. And if you do a search on, for stock photos, you'll find depictions of early humans rubbing sticks together in various forms to create fire.

Dr. Ellery Frahm:
I don't think this is what we should be looking at in terms of the deep past. Yes, absolutely modern humans around the world have used things like the bow drill, but I think these are more recent innovations. What we're looking at in the deep past, at least in my view, is something more like this Swedish woman is doing a hundred years ago using flint and steel. You can't quite see that piece of flint, or chert is another name for it, in her hand, but you can definitely see her steel fire striker.

Dr. Ellery Frahm:
So what's happening when she's doing that, she's holding a piece of flint. This is mostly quartz mineral, and that's what's important. It is probably the hardest substance that people had access to for a long time. And that's what's important. So you'd hold the piece of flint steady in one hand, down comes the steel striker and sparks are released. Why? What is that? That's tiny bits of iron, iron atoms, miniature iron particles being scraped off that steel by the super hard flint. And those iron particles are rapidly oxidizing. So if you remember your fire triangle from elementary school, you need oxygen for there to be fire, that's because it's

largely an oxidation process. So what you're getting is free iron particles in the atmosphere rapidly oxidizing. That chemical reaction is the sparks.

Dr. Ellery Frahm:
It's the same basis for old time flintlock guns. So again, you see here like a spring loaded arm with a piece of flint that would've struck that steel plate and showered down sparks into that little cup of gun powder. And it's not that different from a big lighter or a cigarette lighter today. What's different is that the steel is now the super hard part. And instead of flint, what they call a flint, that's really a soft piece of iron that easily iron atoms can be freed from. So it's that freeing of iron atoms from what we call the flint by the spark wheel, that's really taking the place of the flint, that's creating sparks. So it's named little backwardly. But it's still very similar fire technology.

Dr. Ellery Frahm:
Now, something of importance here is the lighter has lighter fluid. What would be the fuel in the past? We don't have this evidence from anything nearly as old as Neanderthals, but thanks to Ötzi the Iceman who in the Swiss Alps and managed to get covered by a glacier, most of his organic materials were preserved for us to study today. And amongst them was tinder fungus. And you can even see from its Latin name, the fomentarius, for starting a fire, that this is a use that this has had for a very long time. And then there was, he had flint, chert with him. The only thing missing from his fire starting kit would be a piece of what's called marcasite site or pyrite. They're both different forms of iron sulfide. That is the source of the iron atoms. So instead of this steel fire striker, it's this iron sulfide mineral.

Dr. Ellery Frahm:
This is not a stretch. These minerals occur together, chert and pyrite and marcasite can occur together. It's not like it would've been a hugely different occurrence halfway around the globe. And in fact, you can even see here, a flake piece of chert that has these nodules of pyrite directly within it. This easily could have led to being struck as you're making a stone tool and creating sparks being noticed in multiple places around the world.

Dr. Ellery Frahm:
And this was actually examined for some support by Andy Sorenson and colleagues at Leiden. And they looked at a collection of these hand axes. They worked by facially. They expected there to be marks of their use around the edges, kind of the business end of it, but that it would be uncommon on their broad sides to have wear marks. And under a microscope, sure enough, there are these long striations that match their experimental tests of striking hand axes with marcasite or pyrite to start fires. So again, we have here closely related technologies. It would not be a stretch to have pyrite and marcasite occur alongside chert. And if you are striking one with a hammer stone, you can strike another with a hammer stone.

Dr. Ellery Frahm:
So bringing it back to the hall of origins where we started with this heidelbergensis, like I said, everything is up for debate I would say, beyond what's just my opinion, in terms of the timing of fire use. But I hope that what I've shown you here is that this scenario here is entirely possible in terms of what could have happened in our human evolution. I want to thank many, many people who have facilitated our research that you've seen here and supported my work. And with that, I am happy to end the screen share and take questions.

Briana Pobiner:
Thank you so much. That was a fascinating talk and your visuals were wonderful. So I really enjoyed that. And we have some questions coming in already.

Dr. Ellery Frahm:
Excellent.

Briana Pobiner:
I will start with a question from Aisha, how hot can fire get?

Dr. Ellery Frahm:
Yeah, so that is a fabulous question. That's the challenge essentially for what has been a limitation on our technologies, right? And so if we're just talking about cooking, being at early human technology over a campfire, a few hundred degrees is not outside what's typical. If we're talking about smelting copper or to make bronze, then you're talking about in Fahrenheit 2000 degrees or something like that. So that has been one of the constraints on human technology, is how long can you control the fire? How long can you keep it going? And what temperatures can you reach?

Dr. Ellery Frahm:
And then there're all sorts of interconnectedness. So if you're going to turn metal ore into metal, you don't just need the fire, you also need like the ceramics to smelt them in as well. So all these technologies really build on each other and you need the previous steps to get to the next step. So it depends on what time period you're talking about and everything from fuel from an ancient campfire to a blast furnace to make steel or something like that. That's a good question.

Briana Pobiner:
Got it. Thank you. Here's a question from Neils who asks, how does carrying fire from one place to another fit into the evolution of this technology, as opposed to, I guess just starting it, keeping it going, but moving it around?

Dr. Ellery Frahm:
Yeah, that's a really good question, too. Certainly there were like fire boxes, containers that were sometimes like a shell or something that wasn't going to burn, that could have something like the tinder fungus smoldering. How that fits in the paleolithic is extremely hard to tell. And that comes down to, again, a lot of the arguments of who could start fire when? Did you have to rely on those lightning strikes? And when you saw there was fire, you ran to it instead of away from it to try and capture it, to keep going somehow.

Dr. Ellery Frahm:
So I would say, again, that's an open question that largely depends on which side of all these debates you fall on. It's probably something that maybe wasn't clear that it was an important point I wanted to make is that it's not necessarily the case that Neanderthals could or couldn't start fire. Or that heidelbergensis did or didn't cook fire. I don't think it was nearly that binary. I think just as human cultures today live differently and have different subsistence practices, there were probably groups of Neanderthals who could start fire and groups who couldn't. And that they had to learn kind of from each other how to actually start it on demand.

Dr. Ellery Frahm:
So again, it's one of these fascinating questions that we just can't answer yet. And hopefully once we are developing more and more of these technologies, whether it's again, the chemistry, or whether we're looking at things like magnetic signals in the past for fire, we can get past this restriction of fire evidence that is required us to just look for burned bone in sediments and stuff like that.

Briana Pobiner:
Actually, that leads very well into two similar questions that I'll ask together speaking of types of evidence. So Vatal asked, is there any evidence of flint at

cave and fire sites? And Lynn asked, are other are common findings at the sites that support the manipulation of fire, like the remains of larger animals, evidence of cultivated food, cave drawings, et cetera?

Dr. Ellery Frahm:
Yeah. Those are all fantastic questions. So almost anywhere you have what's been reconstructed as a hearth. So the fancy name for fireplace in a cave. There's almost always people weren't just there doing to start a fire. They weren't teenagers. There was a campsite. And so there's often bits of stone, whether it's a raw material workshop or whether they're just re-sharpening the tools that they have and animal processing. Your life depended on having your stone tools with you and being able to know where animals were. So the one site that we looked at before at Lusakert, there was that profile where there was the little depression where there's the ashes, and the evidence for burnt bone. But there's also lots of bits of broken bone. Most of it is horse that they would've been eating. And then again, tens of thousands of stone tools. And that's because there's an obsidian source right nearby. So those are very common bits of evidence together.

Dr. Ellery Frahm:
Other types of evidence, some types of stone will, if they're heated. I mean, you can imagine just tossing bits of stone into a fire, especially if you're working on it, sharpening your tool, that will exhibit evidence of having been heated to high temperatures too. Sometimes that is visible on the surface, other times we can recognize it through changes in the minerals. Certain minerals that carry magnetic signatures, if they're heated above like 600 degrees C, will change in their signals.

Dr. Ellery Frahm:
Cave paintings, there's only one very contentious site in Spain that might have cave paintings that fit Neanderthal time periods. But they're very abstract, nothing like Lascaux or something like that.

Briana Pobiner:
Excellent. Thank you. We have a ton of questions pouring in. This is fun.

Dr. Ellery Frahm:
Perfect. I'll go as long as you'll...

Briana Pobiner:
Well, we'll end at 12:30, but...

Dr. Ellery Frahm:
Yeah, exactly.

Briana Pobiner:
So I'm going to combine also two similar questions or at least on the same theme, a question by Harry who asked, given mode 3 timeline, can we assume that brain development occurred independent of fire itself? And then there's a question Donna asked, is it likely of the use of fire to prepare food led to improved human nutrition and thus brain growth? And we will get to also similar questions after that.

Dr. Ellery Frahm:
Yes. There are big suggestions that some brain growth and also some supposed digestive changes with Homo erectus might have been linked to cooking. There is your own recent work about what role did or didn't meat eating play in brain development. A lot of these fall more on the kind of hypothetical side for me, especially because of the great time depths we're looking at. There was even a recent, a book that came out a few years ago that argued our shift towards being

from nocturnal to diurnal animals was related to firelight and stuff like that. But again, that would push fire back many millions of years. And we're kind of beyond the ability to test those sorts of things.

Dr. Ellery Frahm:
So I think there's been, in terms of the cooking, that's certainly been, but that would put fire back farther than we have evidence for. And it depends if you're comfortable with that. Same with brain development. There's so many question marks on that timeline right now that make it really hard to have firm arguments beyond like the nutritional things that have been investigated recently. Same thing with that whole nocturnal to diurnal shift, that there's kind of a proposed neurochemical link, but it's such a fragile change to me that I don't really buy it.

Briana Pobiner:
Speaking of cooking, we do have a couple questions about that, unsurprisingly. So Ron asked, how long after the discovery of fire did cooking start? And Jack asked, why did early humans transition to cooking food with fire? Was there a clear benefit to cooking?

Dr. Ellery Frahm:
Yeah, I mean, I think those... So the first one, it was... Give me the exact phrasing on the first one. It was, is there...

Briana Pobiner:
It was how long... Hold on. Let me get back to it.

Dr. Ellery Frahm:
Oh, that's right.

Briana Pobiner:
How long after the discovery of fire did cooking start?

Dr. Ellery Frahm:
Yeah. So that again falls into our category of it's really hard to say much at this point. I would say we were probably familiar with fire effects before controlling it. And so finding... If we were exploring what was in where a forest fire was, or natural fire, finding plants that were cooked or dead animals that had been roasted or something like that. I think cooking, natural cooking was probably in our repertoire before starting fire, if I had to guess, but that's just a guess.

Dr. Ellery Frahm:
And yeah, these questions are great because they've weighted exactly into the debates that have existed for a long time. And I think right now, it's so hard to answer them because we've been stuck with traditional evidence of fire and we're getting more and more sophisticated being able to recognize the past. I would love to be able to tell you or be the one to find it, but we just don't have that yet. We don't have that resolution.

Briana Pobiner:
Yeah. That's fair. Here's a question from Rick who asks, at the sites in Armenia, where you have worked and studied fire residues, the dates seemed to overlap one of the times when homo sapiens spread from Africa to other places in the world. Could modern humans, rather than the neanderthals been responsible for those in cave fires?

Dr. Ellery Frahm:
So that's a complicated question. There are not a lot of good... We don't have good bone preservation throughout most of the Caucasus. It's not as good as the Levant,

which is the Eastern Mediterranean coast of what's now Israel and Palestine and Jordan and Lebanon and Syria, stuff like that. So there, there's better bone preservation that allows us to make better species attributions. In Armenia and Georgia, and most of the whole Caucasus region, we're lucky if there's a tooth. And how much can a tooth, especially if it's a juvenile tooth and the DNA hasn't preserved, you're just kind of stuck with some educated guesswork about which human species that reflects. And most of the time, there's assumptions just based on those stone tool types that aren't necessarily justified. So if we find those mode 3 lithics, we tend to say there's Neanderthals there. If there's what's next called mode four, we assume that they're modern humans.

Dr. Ellery Frahm:
That to the extent to which human fossils are found has been supported, but it's not necessarily a good assumption. So one of the things that is going to allow better resolution worldwide is like the DNA testing from sediments, that we can start to be able to say for certain, there were Neanderthals here, there were modern humans here, stuff like that. But the short answer for that so far is that further south in the near east, in the Levant, yes, there were definitely neanderthals and modern humans overlapping even earlier than that. But as far as we know, the Caucasus is much more like the rest of Europe where there was not the same sort of overlap. And the transition happened somewhere probably at about 45-40,000 years ago.

Briana Pobiner:
Well, new techniques hopefully will help us answer some of these questions that are difficult to answer.

Dr. Ellery Frahm:
It keeps us employed.

Briana Pobiner:
Exactly. That's right. So here's a good question from Sarah that's one of those. Why do you think we don't find evidence questions? So Sarah asks, what do you think lack of fire evidence at Neanderthals sites during glacial periods? Do you think they were not using it frequently and enough to leave evidence? Or do you think it's more likely that we're missing the evidence from differences in site function between cave sites and open air sites?

Dr. Ellery Frahm:
Oh, yes. That's a fantastic question. It's probably a little bit of both. So I would say, you are not visiting cave sites just for fun, you're there following something. So there are sites we know that's where the goat migration happens seasonally. And if you're Neanderthal you know, "I need to be here at this point in time to get the goats or I'm starving for a while." So they have that level of sophistication of knowing where they needed to be, when. If during a cold period, those animals their migration routes have changed, then you don't have reason to visit those sites. So if the resources have changed in their distribution of the landscape where you're going to visit is going to differ too. So it's partly like what we just said, is essentially site use or even site disuse.

Dr. Ellery Frahm:
And then there's long been assumption also I would say that caves, certainly these preserve better at caves versus open air sites, like the question asked. But also just the idea that caves are somehow this like sealed bottle of the world and nothing comes back out again or something like that. And we definitely know that, that's not the case. And that even something as simple as freezing and dying in ice actually during a cold period, might just have broken up bits of charcoal and bits of burnt bone to the point that we can't recognize it. So I think it's part preservation and part you very well might not have visited the same places during

glacial periods and interglacial periods.

Briana Pobiner:
So here's an interesting question about a specific site. [Urote 00:49:05] asks, can you comment on the recent work out of Lazaret cave in France that indicates that 170,000 years ago, early human strategically located their herds in caves. Does this support your ideas?

Dr. Ellery Frahm:
Yes, I can comment. It does not surprise me whatsoever what they found. It is not a new problem that we have when we sit around a campfire in our backyards and try and not breathe in a face full of smoke. So you want to sit close, but you don't want to choke. We have had this problem forever, especially if you're in a cave. So again, humans are precocious enough as we've established, that I have no doubt that they could figure out, if we put the fire here, we don't suffocate and die. And especially those humans that did that would be weeded out.

Dr. Ellery Frahm:
What's interesting, and what that paper didn't address is that it's also been suggested that, at least the original excavator, suggested that certain points in time, there was maybe even like a temporary like animal skin enclosure over the front of the cave too at different points in time. And that could have changed airflow too. But yes, I saw that and it made perfect sense. I thought it was very cleverly done though, the modeling that they did. But it makes perfect sense.

Briana Pobiner:
Nice. Here's the question from Peter, he said in Braiding Sweetgrass, the author notes that native Americans used liken a form of tinder fungus to ignite fire very easily. And he asks, is that the same material?

Dr. Ellery Frahm:
It's not the same material as, as the tinder fungus, but certainly you need something that's not... it's like any sort of tinder to start a campfire or something like that. You need something light, whether you're using... I'm sure people use whatever they have. If they were milkweed pods, they used milkweed pods. If they had like in this, like in that. So it's similar, but this tinder fungus, it also is the nickname, something about like horse hoof for something like that actually looks the side of a tree like a horse's hoof. And inside is really the fluffier stuff that ignites well.

Briana Pobiner:
Nice. This is, I think various question, which you can have fun speculating, should you so choose. Sandy asks, did the technical discoveries you have made help explain why humans developed myths and legends about Gods giving them fire.

Dr. Ellery Frahm:
There's Prometheus like an antique French trading card with... So I don't see why not. There certainly are recurring themes there. I mean, I think that a lot of the technologies that are related to fire have had, at least in some cultures, are kind of magical aspects to it, especially when it involves transformation from one form to another. There are even some people... Like I said, sometimes you can tell when stone has been heated and stuff like that. And there has been huge debates whether that even improves it or whether people just thought the color changed from kind of tan to red was cool and magical, "Hey, look at this," rather than, "This makes it flick better," and stuff like that. I mean, there's a lot of myths all around the world.

Dr. Ellery Frahm:
I don't know that our specific technologies can do that, but certainly having two

of the stones that are slightly special type, and you do the same thing, you've done to make tools over and over again, but now with these special ones, there's fire, there's sparks, there's heat, there's warmth, there's shadows, it's something else. I mean, that must have seemed magical. But yeah, I am really fascinated by the myths and cultural... The there's many, many cultural traditions even today involving fire. And those that... Yesterday was the last Wednesday before Persian new year. And there's a tradition of jumping over fires that dates back to [inaudible 00:54:28] and stuff like that. There's all sorts of amazing stories and stuff like that. Now, do they go back 300,000 years ago? I would say there's often an association between not just fire, but the ways we've used it that have been magical.

Briana Pobiner:
Oh, I like that. We have time for probably one or two more questions. And here's... I think we'll have time for two more questions. Here's one, which is a good, what kind of evidence would we need to answer that question? So Mark says, or asks, children in forest schools use hair as tinder. Might early humans have done that or used that?

Dr. Ellery Frahm:
Yeah, sure. Why not? I mean, and again, if you look at reconstructions of Neanderthals in museums, they've gone from being full hairy cavemen to more short than I am, because your stone tools are razor sharp. So they certainly would've had the tools to easily cut hair and use that as tinder.

Briana Pobiner:
That makes sense to me. And now I am looking for the last question that I had flagged to ask. Oh, there it is. Okay. So question from Sandy, and maybe we will get one more after this. We'll see.

Dr. Ellery Frahm:
Sure.

Briana Pobiner:
About sort of communicating about your research. So Sandy says, I used the figure of 1.6 million years ago for the commencement of control of fire for my school talks based on South African dates. And then I explore with students the benefits of fire and explanation of enormous growth of brain size. Is this reasonable still?

Dr. Ellery Frahm:
Ooh. Who do I want to annoy today? This is probably Wonderwerk cave in South Africa, that somewhere again, there's different layers, that there's different arguments. So somewhere between 1 and 1.6 million years ago. It goes back and forth. Is it good evidence? Is it not? Did it blow in? Is it ash blown in from the outside or is it in situ? I think it is perfectly reasonable to investigate it. I don't know if I would link it to enormous brain growth, but I do think one of the things that's interesting about this topic is kind of the way I structured it today. There's a lot of learning about evidence and arguments and how we go about doing these investigations. If you're a teacher, science being more of a verb than a noun, is important. And just like you saw with Zhoukoudian cave, that the dates get better as our technologies advance. And so using that as an instance to learn about science, I think is how, if I was asked to teach an elementary school class about that, I would do it from that perspective.

Briana Pobiner:
That's excellent. I think, although I was going to end on that question, I'm going to get one more in, and I apologize to everyone who submitted great questions that we won't have a chance to answer. But Caroline asks, thinking of caves like Chauvet, do you think that fire was integrated with art?

Dr. Ellery Frahm:
Yeah. There's a lot of instances where cave, cave paintings, there are some structures inside of caves that seem to date to Neanderthal time, but these are beyond natural light. So the only way they would've been illuminated is with fire. And if one wanted to argue that the dancing flames helped make the pictures move or something like that, certainly I wouldn't look at this cave art with an LED flood light today and interpret it in that sense. The artist's intent would've been that it be viewed with a torch or something like that. I think that's a really interesting idea.

Briana Pobiner:
Excellent. So thank you. I'm going to wrap things up today. Please join me in thanking Ellery for sharing his work with us. And I'd also like to give special thanks to those who made this program possible, to our behind the scenes team who helps sort through your questions, to our donors, volunteers, and viewers like you. And finally, to all our partners who help us reach, educate, and empower millions of people around the world today and every day. Thank you.

Briana Pobiner:
I hope you'll join us for our Hot Topic program next month on Thursday, April 21st at 11:30 AM with Dr. Kevin Uno from Lamont-Doherty Earth Observatory of Columbia University presenting what do molecules in mud tell us about the environments of early human ancestors? Check back on our website for more information about that program soon. And we've put a link in the Q&A where you can find information about our upcoming programs and how to sign up for the Museum's weekly eNewsletter. That's really the best way to stay informed on upcoming programs and learn more about the Museum's research and exhibitions. Right after this webinar ends, you'll see a survey pop up, asking for some feedback about the program. Please take a moment to respond. We're very curious to know what topics you might be interested in seeing for future programs, and we appreciate your input.

Briana Pobiner:
So again, thank you, Ellery, thank you to our participants behind the scenes and to you, the audience. And we look forward to seeing you next month. And again, happy anniversary to the Hall of Human Origins, which opened 12 years ago today. Bye, everyone.