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**0:00:05.9 Meagan Cantwell:** Welcome to the Science Podcast for January 1st 2021. I'm Meagan Cantwell. Each week we feature the most interesting news and research published in Science and the sister journals. First, we turn to the areas of research and policy our reporters will be watching this year from rovers landing on Mars to understanding the social ties of ancient humans. Also this week, I speak with Leda Kobziar about an overlooked aspect of wildfire smoke, the microbes they carry.

**0:00:40.4 MC:** First up, we have Ann Gibbons. She's a contributing correspondent at Science. She'll be looking out for studies that examine the social relationships between ancient humans. Thank you so much for joining me. Ann.

**0:00:50.5 Ann Gibbons:** Happy to be here.

**0:00:51.0 MC:** One of the things you highlighted last year as an area to watch was analyzing ancient proteins as a way to examine the lives of past people. Do you think the advancements from this past year is gonna help these upcoming studies?

**0:01:04.8 AG:** Absolutely, so these teams now are including specialists in all sorts of areas, whether it's ancient DNA or proteins, or analyzing the bacteria that are in the teeth, plaque, or other angles of evidence that are available, and when they put the stuff together, they can begin to look at things like, not only the identity of the people who lived there, but if they're lucky enough to have generations of burials in a plot, they can begin to look at patterns like who inherited the wealth? Was it the young man? Was it the oldest son? Were the men related to each other who inherited the wealth? Or did the women inherit the wealth? Also who is missing? Who is rotating out? What are the marriage patterns there?

**0:01:41.2 AG:** For example, one site, we wrote about, in the past couple of years, in Germany, the young women of high social status were missing, so they were probably leaving home to find husbands. You might also have people of different rank buried in one site, so you might have people with a lot of grey goods that are wealthy, and you might have people that are not well off in the same cemetery, this happened at a Lombard site in Italy. And so the question was where these people, their workers, were they slaves? Who were they?

**0:02:09.2 MC:** There have been studies already about these things and you expect more in the upcoming year. Another thing that you highlighted was potentially analyzing these mummies in China and Egypt, what are researchers hoping to learn about these?

**0:02:21.1 AG:** There are some famous mummies that are in China whose identity has long been a big question, were they Caucasian? Were they local? The new tools are going to be able to help us identify their identity, which will tell us a lot about migrations and the diversity of the people living in these areas, what they look like, we're gonna be able to sort out identities of key populations in sites that are identified by the culture, but hopefully, the DNA and the isotopes in the bones where they came from originally.

**0:02:50.8 MC:** What would you say you're the most excited for?

**0:02:53.8 AG:** There are some really cool studies on Anglo-Saxons, the early Angles and Saxons in Europe who moved into the UK. Who are these people? What's the diversity? How are they related to Vikings? How are they related to other groups? The same with the Celts. The word Celtic means other, it's not one biological group, so who are the different groups that are making up these interesting cultures? They're probably gonna be fairly diverse. I like this notion that the DNA shows us a lot about mixing and that these famous cultures we've known about, the archeological record often have really interesting origins that are more diverse than we thought. I'm pretty excited about the power of the dietary studies as well, to show us a little more about the origins of spice trade and different foods that people were eating as well and how some of these cuisines, we think of like the Middle Eastern cuisine, were the first global cuisines? How did they come together? Who were the people that brought these foods? These kinds of questions we're gonna get more insight into.

**0:03:51.5 MC:** There are so many new techniques coming out too. It just seems like it keeps getting richer and richer, right, the more information that you can pull from these sites.

**0:03:58.4 AG:** Absolutely, I will say the thing that has changed the most in the years that I've been covering archaeology and human evolution, it's not about the methods to find the bones or the fossils. What has changed is the tools that scientists can now apply to the remains and to the sites, and it's not just to the human bones, it's also the archeological artifacts, to the soils, to the geology, to see how the site was formed, how old it was, all these methods are getting better, and you begin to get this sort of a landscape approach that can be very rich where the preservation is good enough to do that.

**0:04:30.0 MC:** A lot to look forward to. I'm really excited to read your takes on them next year, Ann, thank you so much.

**0:04:35.3 AG:** Take care, thank you.

**0:04:36.0 MC:** Now we have Jeffrey Mervis, a senior correspondent for Science. He says the relationship between the US and China is one to watch this upcoming year. How are you doing, Jeff?

**0:04:47.7 Jeffrey Mervis:** Hi, I'm fine.

**0:04:49.3 MC:** What has the relationship between the US and China been like during the Trump administration?

**0:04:52.4 JM:** Well, that's an important question but it's hard to answer because it has many facets. So the biggest issue for the US scientific community has been the fear of restrictions on their ability to collaborate. Now that's apart from any trade war for any economic sanctions, but the fallout from those tensions between the two governments has been felt by the scientists, and specifically the issue of whether Chinese entities are having a negative impact on US-funded research.

**0:05:36.7 MC:** You reported earlier this year about the National Institutes of Health investigation that resulted in 54 scientists losing their jobs because they weren't disclosing financial ties to China. So it seems like a lot of the national security concerns stem from this lack of transparency about whose funding scientific research.

**0:05:55.0 JM:** Right, so what the policymakers are most concerned about is that US scientists that are getting federal grants might be sharing information with foreign governments, and therefore that the US government isn't getting the full focus of the research, but it's a very difficult thing to pin down because at the same time, the idea of collaborating with anyone around the world is something that everyone supports.

**0:06:30.4 MC:** And another way that things have been strained is Trump's inaction of restricted immigration policies that's made it harder for students and professors, not only in China, but also other parts of the world to study and work in the US and with the new administration coming in with Biden's administration, do you think there's a chance for this to reverse course?

**0:06:49.8 JM:** That's what the scientific community is hoping for but I think realistically the US and China ties are gonna continue to be fraught and they will spill over into both research and immigration, and then both of those are important for the US scientific enterprise. Members of Congress feel that agencies need to be more aggressive in identifying these potential conflicts. But the hard part is how do you do that without restricting the progress in research? There are many Chinese-born students and Chinese trained students in the US. And although immigration isn't directly related to the disclosure issue, it's become a very controversial area as well.

**0:07:42.3 MC:** So it's all about finding the right balance between collaboration and security, and you mentioned in your item that there is a US government forum that's trying to advise the incoming administration on how to get this balanced. What do you think will come of that? What kind of advice do you think they're giving the incoming administration?

**0:08:00.6 JM:** Balance is the key. And this group, it's called the Round Table, has just started to meet. In fact, they held their first meeting just earlier this month. It's not gonna be making policy, but I think what the community is hoping it will do is provide a forum so that if there are concerns, they can bring them to the attention of policymakers and that whatever an agency decides to do, it will be based on discussions with the research community rather than something that they do preemptively, and then the community has to react to it.

**0:08:41.1 MC:** What do you foresee being any major changes with the new administration coming in when it comes to US-Chinese collaboration for science?

**0:08:50.2 JM:** I think they may not see any significant changes for a while because I think the Biden administration will have to step very carefully to demonstrate that it's not being soft on threats to national security. At the same time, I think as the Biden's administration gets going, there will be a lot of people in that administration who are familiar with the challenges. So I think scientists are hoping that those voices will be part of the discussion and that those people will be at

the table. And they don't think that that was the case in the previous four years during the Trump administration.

**0:09:32.1 MC:** Thank you so much.

**0:09:33.2 JM:** Alright, thank you.

**0:09:35.7 MC:** Last up for this segment, we have staff writer Paul Voosen. He'll be watching out for two potential landings on Mars. Hey, Paul.

**0:09:44.1 Paul Voosen:** Hello.

**0:09:44.2 MC:** This isn't the first time a rover has tried to land on Mars. How have past attempts gone?

**0:09:48.4 PV:** So there have been I think about 18 attempted landings on Mars, nearly half of them have crashed, and really NASA is the only space agency that's had success landing missions there, and that could change this year.

**0:10:04.4 MC:** What's so tricky about landing on Mars? Why have so many of them failed?

**0:10:09.3 PV:** Mars has this really annoying thing called atmosphere, so atmosphere is difficult to go through, it generates heat, but it's a thin atmosphere as well, and so parachutes alone won't do it which means you need some sort of rocket thrusters to do the landing correctly, and that has led to different innovations like the famous Sky Crane last used for the Curiosity Rover.

**0:10:33.7 MC:** Hopefully, these two rovers that are going to land in February will have better luck, and that's Perseverance from NASA and also a rover from China called Tianwen-1. Are these pretty similar rovers, do you think that they could nail this landing?

**0:10:47.2 PV:** So the Perseverance Rover follows a lot from the Curiosity Playbook, it will also have the Sky Crane as some innovations that will allow it to make an even more precise landing very close to its target, so there's a lot of belief that JPL, the NASA Center, that runs this mission will be able to do it again. The other mission, Tianwen-1, will be the first attempt by China to land on the Mars surface, and it's a very ambitious attempt, and there's a lot they can do, it's not nearly as powerful or sophisticated a rover as Perseverance, but there's a lot of new science that could come from it.

**0:11:25.2 MC:** Are they headed to the same region of Mars?

**0:11:28.5 PV:** It's a similar region. Perseverance is going to a place called Jezero crater, which is this fossilized delta that's more than 3 billion years old, and the site where water once existed on the planet. Tianwen is going to Utopia Planitia, which is a very flat lava plain, close by but it's a much safer landing spot with far less obstruction.

**0:11:53.0 MC:** The environments of the areas they're landing are pretty different, so does that mean that the missions can yield different answers about the history of Mars?

**0:12:00.9 PV:** Jezero has a very precise objective to collect rock samples to explore the early history of Mars, searching for evidence of past life or the reasons the climate change from possible watery world to dusty cold barren wasteland. The Tianwen has a more general less site-specific, they'll be looking, they have a radar to hunt for frozen layers of water beneath the surface, and the Chinese Space Agency has done really well with radar on the moon as well. It also has a landing platform and observer that are going to use a lot of similar scientific instruments that you've seen on past NASA and European space agency missions.

**0:12:44.1 MC:** China's mission is not a sample return mission, like Perseverance?

**0:12:47.8 PV:** No, it's not.

**0:12:48.7 MC:** Although they are landing in February, we're probably not gonna see... Well, at least we won't see the sample return for quite some time, when can we expect some preliminary results from this landing?

**0:13:00.3 PV:** Perseverance has a whole variety of scientific instruments beyond the sample collections. It has a lot of discoveries that can make on its own, and of course, Tianwen it'll be producing observations, right, from landing as well. So you'll see a scientific return, the sample collection NASA just greenlighted the best case estimate for that launch in is 2026 to reach in 2028, it will take a decade to get these samples back.

**0:13:27.9 MC:** Thanks so much, Paul.

**0:13:28.4 PV:** You're welcome.

**0:13:29.8 MC:** Those are just a few of Science's areas to watch in 2021. You can find a link to the rest at sciencemag.org/podcasts. Stay tuned for my interview with Leda Kobziar about microbes in wildfire smoke.

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**0:13:50.2 MC:** Wildfire smoke can waft thousands of kilometers away from roaring blazes. As climate change alters where these fires prop up, it will also change where the smoke settles. I'm here with Leda Kobziar to talk about her perspective in Science last week, which tackles what that smoke is carrying and how that impacts ecology and human health. Thanks for joining me, Leda.

**0:14:14.5 Leda Kobziar:** Thank you for having me.

**0:14:15.5 MC:** Of course, first I wanna get started with what exactly happens after a major wildfire? These really big ones can sometimes impact air quality for what seems like weeks at a time. When humans repeatedly inhale this kind of smoke, what does it do to their health?

**0:14:29.8 LK:** It can cause a number of different types of repercussions, both to pulmonary systems and cardiovascular systems. We have a good idea of there being a relationship between the amount of particulate matter in an area and these health consequences. But the thing that we don't have any information about is the other component of the smoke, which is the living component of the smoke.

**0:14:55.3 MC:** I had never thought about the fact that there are microbes, living things being transported through this wafting smoke. What kinds are usually transported?

**0:15:04.3 LK:** We've seen upwards of a thousand different species when we use next-generation sequencing to understand the molecular composition of smoke. We've also seen that scientists have been able to culture a lot of different organisms from smoke, so these include bacteria, fungi, people haven't yet looked at whether or not viruses are also transported this way, but that is, of course, of interest, but the studies that have been produced so far show that these organisms come from soils, they come from plant surfaces and they also come from inside plants and inside decaying matter like downed woody debris on the forest floor, or even something that is buried in the top layer of the soil.

**0:15:47.8 MC:** It was surprising to me that the temperatures from the fire aren't actually enough to kill these microbes. Could you talk about why that is?

**0:15:55.1 LK:** That is something that we have some hypotheses about. The actual heat that is experienced at different scales is very variable. You could even think of it this way as running your finger through a flame. If you do it quickly and it's just your finger, you don't feel any pain. Obviously, if you're subjected to that flame for a longer period of time and it's over a larger part of your body, then the effects are gonna be greater. There has been some work published that shows that some of the assumptions that we've made in the past about how microbes respond to heating during fires is not really true, depending on the species that have potentially a very high capacity for withstanding at least temporary heat transfer.

**0:16:38.6 LK:** They might also be in water droplets, and so they might be protected there. It's very likely that they are attached to a particulate matter as well, and they might find some protection in that particulate matter.

**0:16:51.5 MC:** The transport of these microbes, like you said, hasn't been studied at length yet, but what are some of the lines of evidence that you've seen that these are spreading pretty far and wide from wildfires?

**0:17:01.9 LK:** The research that has been done is, like I said, extremely limited. But we know that there are bioaerosols that exist in ambient conditions and non-smoke conditions, and we know that those are transported across continents, so there really is no reason to think that the organisms that are elevated from the ground level into the atmosphere through smoke and through combustion processes are not equally transported, and what we see is that the numbers and the concentrations of these organisms is extraordinarily high.

**0:17:35.6 LK:** In some of the work that is currently undergoing review for a publication, scientists have seen that there are upwards of 100 trillion cells that are being aerosolized in an area that's burned, let's say just a hectare, so numbers like that are really, really far above what we see in ambient conditions, and about 60% to 80% of those organisms appear to be living, so that all suggests that the transport is very likely.

**0:18:05.4 MC:** There are places around the world that are experiencing wildfires that haven't seen them before, so it's kind of interesting to think about microbes being carried from regions that don't usually experience the effects of wildfire smoke. Does this have repercussions for the ecology of an area, the changing of the microbial community?

**0:18:23.7 LK:** I think that it's very likely to be the case. I mean first, this mechanism has never been considered as a biological dispersal mechanism, and that has probably been at play for as many millions of years as there has been a fire on earth, but in addition to that, like you said, new things are being combusted. We're seeing Arctic soils, for example, that are burning that haven't burned for many millennia. And so that might be introducing a new reservoir of species into ecosystems through the transport of smoke. We have not that much information about how microbes disperse and spread and what that means in terms of biological diversity and all of the different effects that microbes have on the functioning of ecosystems, but we know that they are critically important, so seeing huge numbers of them transported from one place to another, it has effects on the place that they're leaving, and it has effects on where they land.

**0:19:26.0 MC:** In addition to the ecological aspect of this, there is the human health impact. What kind of illnesses can occur from the inhalation of these microbes?

**0:19:34.1 LK:** There are a number of different types of organisms that cause infection in humans, and some of the ones that we think would be most interesting to look at include things like coccidioides, which causes valley fever, and that is one that is found in soils, and when soils are disturbed, the spores are aerosolized. There are some indication of disparate populations of that organism, and the same goes for Cryptococcus gattii, which is a saprophytic organism, a fungi as well. So we think that potentially smoke is the mechanism by which it was moved, and the health consequences are already being documented in a variety of different places. We wrote the piece with the hope that people from a wide variety of different scientific disciplines would start to examine these potentials because there are often cases where an infection is detected in a patient, but because certain organisms are not tested for that we don't have a record of whether or not that is the causative agent.

**0:20:40.4 LK:** So we think that this could help medical professions understand why certain levels of infection, pulmonary infection, respiratory tract infections, why those things are increasing, and what the causative agents could be.

**0:20:54.0 MC:** Usually are those that are closest to the fire most at risk of getting sick from these microbes?

**0:21:00.5 LK:** Sometimes because of the lofting of the smoke plume, it could be that standing near to the fire has less particulate matter in the air, than being 50 miles downwind of the fire, so it really depends on the smoke dynamics, it depends on the fire behavior, and it depends on the amount of energy that's pushing that smoke into the atmosphere, and then what happens to that smoke plume as it travels and gets affected by all of the meteorological conditions that influence the movement of air masses.

**0:21:32.2 MC:** Every situation is gonna be a different transport it will end up in a different place. There's definitely a lot of research, it seems like that needs to be done. I was curious how the research is going about tracking the source of these microbes and where they end up.

**0:21:46.1 LK:** The next step is gonna involve understanding or investigating the distribution of organisms and the source materials that are burning, and then examining what gets aerosolized from that source. So there has been some work that has looked at individual fuel sources, and they suggest that there are some really big differences if you're burning soil versus burning trees versus burning grasses, so the source matters and the conditions of the fire behavior matter as well. So one of the things that we're really interested in working with major teams on is to understand what we are kind of calling biological emission factors, so we have a good idea of how much particulate matter is derived from the burning of a particular fuel type, but we have no idea how much biological emissions are associated with burning that fuel type. Once we have that information, then we could use it to potentially make some links with the potential for disease spread, so this is where the intersection of epidemiology and fire ecology and fire science and smoke science all come together.

**0:23:02.9 MC:** Have you found that all these different fields are interested in this problem or know about this problem, or is it still kind of in its infancy of maybe epidemiologists even understanding that this is a way that these microbes are spread?

**0:23:14.6 LK:** It has been probably just in the last half a year or so that some of these groups are starting to talk to each other. One of the things that I think has always been hard with looking at fire ecology or fire science from an outside perspective, is that the stories that we often hear and tell about fire are simply based on its destructive capacity, and those of us who are fire ecologists, we think about the narrative very differently. We tell the stories about fire creating life and spreading life. So I think some of that is probably what has made moving forward with this line of work more of a challenge. We're very hopeful that this article will inspire some greater collaborations among all of those disciplines that I mentioned earlier.

**0:24:02.3 MC:** I'm looking forward to the future research published about this. Well, thank you so much for taking the time to talk with me.

**0:24:08.0 LK:** Oh, no problem. It's my pleasure.

**0:24:10.0 MC:** Leda Kobziar is an associate professor of Wildland Fire Science in the College of Natural Resources at the University of Idaho. You can find a link to her research at sciencemag.org/podcasts. And that concludes this edition of the Science Podcast. If you have any

comments or suggestions for the show, write to us at Sciencepodcast@aaas.org. You can listen to the show on the Science website at sciencemag.org/podcasts. There you'll find links to the research and news discussed in the episode. And of course, you can subscribe to the podcast anywhere you get your podcasts. This show was edited and produced by Meagan Cantwell with production help from Podigy and Joel Goldberg. Jeffrey Cook composed the music. On behalf of Science Magazine and its publisher, AAAS, thanks for joining us.