00:00 Sarah Crespi: This week's episode is brought to you in part by the American Dental Association. Teeth tell a story. We know what ancient civilizations ate, drank, even where they lived, all from looking at their teeth. What story will your teeth tell about you? Your ADA dentist can help you find out and give you the tools to keep your teeth healthy for years to come. Use the American Dental Association's Find-a-Dentist tool to find the right dentist for you. Go to ada.org/sciencemag today.

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00:35 SC: Welcome to the Science Podcast for November 9, 2018. I'm Sarah Crespi. In this week's show, I talked with online news editor David Grimm about a rise in research using monkeys. And Meagan Cantwell talks with news writer Adrian Cho about the upcoming changes to standards for measurement, like the meter and the kilogram.

00:58 SC: All right. Well, now we have David Grimm, online news editor for Science. And we're gonna talk about monkey research on the rise. Dave, what have you found out about increases in the use of non-human primates by researchers in the US?

01:12 David Grimm: Well, the USDA, the United States Department of Agriculture, recently released its usage statistics. Basically, USDA tracks the number of animals used in biomedical research every year, and they post a report. And this year's report, this covers 2017, is showing a record high number of non-human primates. And that essentially means monkeys, in this case, being used in biomedical research, about 76,000, which is the highest, it seems, to have ever been, and the trends have been inching upwards for the last few years.

01:44 SC: What proportion of animal research is comprised of these non-human primates?

01:49 DG: It's actually a pretty small percentage, about 0.5%. The vast majority of animals used in research are mice and rats, although they are not recorded by USDA because they're not covered by the Animal Welfare Act, so we don't have data on them. But we have data on animals like cats, dogs, guinea pigs, rabbits, things like that. And all those animals are at lower levels than they were 10 years ago, and only the monkeys are at higher levels than they were 10 years ago.

02:15 SC: I'm sure there's a lot of speculation on why these numbers are going up, and one of them must be they're needed for particular kinds of research. What kinds of research are people increasingly using monkeys for?

02:27 DG: Right, and that's what a lot of the biomedical research advocates are saying, that these animals are really needed more than... We've got emerging infectious diseases, like Zika. We're really starting to get a better understanding of the brain, things like Alzheimer's, even developing things like interfaces where the brain can control prosthetics, and all those things, they say, really require monkey researches, not the kind of research you could do in a rat or a rabbit or anything like

that.

02:53 SC: What about drug research? There's been this translation problem for so long, and mice and rats have been considered the culprit. Do researchers think that monkeys are gonna help close that gap?

03:03 DG: Yeah, that's what they say. They say there's a reason that the vast majority of drugs that work in rodents don't work in humans is because they're so different than us. And non-human primates, like monkeys, are so similar to us genetically, biologically. The argument is that we should be testing, making more of an effort to make sure the drugs work in them before they go on to human studies, and because we're trying to develop all these drugs for things like depression, Alzheimer's, things that really deal with the brain, and you want an animal whose brain is pretty similar to ours. They're saying these animals are really gonna be needed more than ever. And, in fact, the National Institutes of Health is saying that the demand for monkeys is really gonna probably increase over the next few years just because of things like this.

03:41 SC: Usually when you and I talk about research animals, we're talking about chimps because there's been so many regulations put in place on their use in the US. That hasn't been happening with monkeys at all? Is that somehow a trade-off that might have occurred?

03:54 DG: That's a good question. There is actually no biomedical research on chimps allowed anymore in the US, so all chimpanzees who are still in labs are theoretically on their way to being retired. And the way that we got there was NIH commissioned a report a few years back that really was asking tough questions about whether we really needed chimpanzees in biomedical research, and the report came to the conclusion that we did, that they really had improved to be the useful model that we thought they were, and it wasn't just... It wasn't worth the cost to use them. And so a lot of animal advocates were saying we should really do the same thing with monkeys. We really need to take a hard look at whether... Just because we think these animals are gonna be better for biomedical research, they're saying that we really need to take a hard look at these animals and figure out are they really better, really, really solve this reproducibility crisis, this translatability crisis, or are they destined for the same path as chimpanzees, where we're eventually gonna see a phase out of these animals as well.

04:48 SC: We should really mention which kinds of monkeys that are being used in their research. What are the most common monkey research animals?

04:56 DG: Yeah. The most common are macaques, especially rhesus macaques. Animals like baboons make up a very small percentage. It's mostly varied species of macaque.

05:06 SC: We can't not mention marmosets. There was another story, a week or two ago, about they're used in research and how that's been changing.

05:14 DG: Right. And the interesting story with marmosets, which actually only make up a pretty small fraction of the monkeys being used right now, but they're really becoming in demand for a lot of genetic research and a lot of transgenic animal research. And the idea is that demand is actually

so high for marmosets right now that we can't... The US actually can't meet supply. Some biomedical researchers are worried the same thing is starting to happen for other monkeys as well, like rhesus macaques, that because the demand for cures for AIDS and all types of things like that is so high that we actually don't... As many monkeys as we're using, we actually may need more and are there enough available for the type of research that scientists want to do.

05:55 SC: We have a bunch of different things happening. We're seeing a lot more use of monkeys in research, even perhaps demand outstripping supply. And then there are people who are not happy about this and who are probably gonna try the same route that they took for chimps. So, what's next?

06:10 DG: Well, some of the animal advocacy groups really want Congress to put pressure on agencies, like the NIH, really force them to take a hard look at these types of [06:19] ____, whether they're really needed. On the other hand, biomedical researchers say, "The public wants cures." The public has made it clear they want cures for AIDS, they want cures for Alzheimer's, they want cures for depression, and they're basically saying, "The public can't have it both ways. If you guys want these cures, we're gonna use these animals." So, this is a fight that's likely to probably get worse in the coming years.

06:42 SC: All right. Thank you so much, Dave.

06:43 DG: Thanks, Sarah.

06:45 SC: David Grimm is the online news editor for Science. You can find the link to his story at news at sciencemag.org. Stay tuned for Meagan Cantwell's interview with Adrian Cho on upcoming changes to international standards on measurement.

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07:01 SC: This episode is also brought to you in part by OpsGenie, incidents happen and they require complex coordination between operations and software development teams who are putting out fires every day. That's why getting alerts immediately is critical. Thankfully, there's OpsGenie by Atlassian. OpsGenie empowers dev and ops teams to plan for service disruptions and stay in control during incidents. It also gives teams the power to respond quickly and efficiently to unplanned issues, and helps to notify all the right people through a smart combination of scheduling and escalation pass that account for things like timezones and holidays. Better yet, OpsGenie allows for deep flexibility, and how, when and where alerts are deployed. With over 200 integrations, like Jira, Amazon, Cloud Watch, Data Dog, New Relic, and more, plus it tracks all activity and provides useful insights to improve future incident responses. With OpsGenie, your next incident doesn't stand a chance. Visit opsgenie.com to sign up to get a free company account, and add up to five team members. That's opsgenie.com, opsgenie.com. Never miss a critical alert again with OpsGenie.

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08:18 SC: This episode is also brought to you in part by the NSA. Almost every day we hear something on the news about a cyber attack. Sometimes it's just some pranksters, but more often it's a foreign country with vast cyber resources trying to hack the power grid, the banking system, or the military's information networks. The National Security Agency plays a big part in protecting the country from cyber attacks, and you could help. The NSA is hiring technical professionals to serve on the front lines of information security. If you work in computer science, networking, programming or electrical engineering, you can help keep the country safe. Design new hardware systems and networks, write faster, smarter programs, protect America's critical infrastructure, or help uncover what its adversaries are planning to do next. Learn more about careers at the National Security Agency today, visit intelligencecareers.gov/nsa. That's intelligencecareers.gov/nsa.

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09:22 Meagan Cantwell: For a vast majority of the world, excluding the US, Burma and Liberia, the metric system is the official system of measurements and weights. Staff writer Adrian Cho is here to talk about how an upcoming meeting in France, the 26th General Conference on Weights and Measurements, which occurs about every four years, may shake up how we define measurements that have been used for hundreds of years. Hey, Adrian.

09:45 Adrian Cho: Hi, Meagan. How are you?

09:45 MC: Doing well. How are you?

09:47 AC: Very good.

09:47 MC: This is the 26th conference that's being held. Are there usually significant changes that occur to units every single time they meet?

09:55 AC: Well, usually there's either a proposal to change something or there is an update. But this one is a pretty significant one in that not only are they changing, say, one specific unit, but they're re-conceptualizing the entire SI system.

10:11 MC: What are the units that are set to be redefined or re-conceptualized?

10:15 AC: There are seven base units in the SI system, and four of them are going to be redefined. And those are the kilogram, the mole, the Kelvin, and the ampere. And the other three, the seconds, the meter, and the candela, which is a measurement of the brightness of light, had been redefined in much the same way earlier.

10:40 MC: Got you. Let's go into more detail about how each of these units will be defined. Currently, the kilogram is defined as the mass of a cylinder of platinum and iridium stored in the International Bureau of Weights and Measurements. How do they plan on defining the kilogram now without this physical reference?

10:57 AC: Yeah. It's tricky, and the best way to explain it is to explain what they did in 1983 in

redefining the meter. Up to 1983, you had seconds that were defined one way, and meters which are obviously different and were defined independently. To make their definition the meter more precise, they would change things around. And what they would do is that they would define the speed of light to have a precise value, so there'd be no uncertainty in it anymore. So, they set the speed of light as a constant exact number, and then they were able to turn the meter into something that you could actually go out and measure, and that would be the standard meter.

11:33 AC: So, they're doing something very similar with the kilogram, except that they're defining constant, called Planck's constant, which shows up in quantum mechanics. And basically, if people are familiar with it at all, it's because the energy of a photon, or a quantum of light, is given by Planck's constant times the frequency of the photon. And it turns out that if you define Planck's constant, then you can turn things around and you can measure out an absolute kilogram with essentially an electrical balance, and so you would replace this one slug of platinum-iridium, which is the kilogram, with these electrical balances of which there are a few around the world.

12:15 MC: So, now, instead of defining the kilogram by this physical reference, they're defining it in terms of Planck's constant.

12:20 AC: That's right. That's completely right.

12:22 MC: But how is this gonna change in terms of experimentation and measuring things out? It's gonna be pretty complicated. Right?

12:28 AC: It is pretty tremendously complicated. Even the people who are involved in this admit that it's complicated. The speed of light thing is pretty easy. You get this idea, "Okay, if I define the speed, then all I need to do is figure out how far light travels in a particular given time, and then I've got the meter." But these so-called Kibble balances that are used to measure out the kilogram are a lot more complicated, but the fact is that if you have a Kibble balance and it's well tuned, you can knock out a standard kilogram weight very easily. This makes the system much more flexible because you don't just have that single reference. If you have a well-defined Kibble balance, you can make your own reference weights. And so that's the idea behind this.

13:15 MC: Did people have other propositions on how to redefine the kilogram?

13:19 AC: Well, there are other ways that you could conceive of doing this. You could conceive of saying, "I'm going to define the mass of carbon-12 atom to be some tiny fraction of a kilogram, and therefore a kilogram is equal to the mass of some gigantic number of carbon-12 atoms." The reason they didn't do that, one is that counting up all those atoms is really, really hard. And the other reason was exactly because the Kibble balance works by bringing in these quantum devices to measure electrical resistances and voltages, and those techniques are exquisitely precise, but they're not actually part of the SI. They're sort of these techniques that have been invented outside of the SI and have never been brought in. Some people have complained that the redefinition is gonna be really confusing and really hard to get your arms around, but there are specific practical reasons that they did it this way.

14:09 MC: Now, moving on to some other units that are planned to be redefined, what's going to happen with the Kelvin?

14:15 AC: The degree Kelvin, which is the absolute temperature scale, it used to be that there's one very specific temperature called the triple point of water, at which water, liquid vapor and solid can all co-exist. And that temperature was defined as 273.16 Kelvin. And so if you wanted to determine what the Kelvin was you had to set up an experiment that held water at that temperature, and then you would divide whatever temperature you got, however you were gonna measure it, by 273. And now what they've done is they've defined this thing called Boltzmann's constant which always relates to, say, the temperature of a material to the amount of thermal energy in it. If you know Boltzmann's constant, you work through a bunch of math and you can get the temperature. And the beauty of that system is that it's no longer tied to the specific temperature where the definition would be most accurate.

15:07 MC: Who are the proponents for these changes, and who are the people that are pushing back and saying, "This could cause a lot of confusion, maybe we should think of another way to redefine it"?

15:16 AC: This has really come out of the metrology community. They have developed this consensus that this is much more reliable system. But, that said, even the people who are strongly for this and who have been working for more than a decade to get the precise measurements of the constants that you'll need to fix them, they admit or acknowledge that this is going to be a little bit tough on people. People generally learn about units and weights and all that in middle school, and it's pretty easy to understand if a meter is the length of a meter stick, and a kilogram is a weight of a particular weight. But when it's tied to some constant in quantum physics that people have never heard of, it's going to be a little bit harder for them to get their heads around.

15:56 MC: Yeah. It takes a lot more background knowledge to even understand that. So, if those changes will... Like you said, they most likely will be approved, how long will it take for them to be implemented?

16:06 AC: Everybody I spoke to is pretty sure that this is going to happen. One researcher told me that they've already scheduled the party, so it seems likely that this is going to go through. But the world would get about six months to get used to the new idea. It must be said, most of us never deal with this. We don't worry about how a second is defined or how a meter is defined.

16:29 MC: Right. 'Cause the value itself isn't changing, it's just the conceptualization behind it. So, it's not like people are gonna have to go buy new scales or anything like that.

16:37 AC: Right. That's absolutely right. So, what they did is that they've put in well more than a decade worth of effort to try to measure the different constants that they're gonna fix now to exquisite precision because once you fix them, there's no going back. Planck's constant will have this exact value, and so they couldn't have five groups around the world measuring this thing with wildly different numbers. They all had to converge. This was actually supposed to happen back in 2014, in a general conference on weights and measures, then looked at this and said that the

numbers weren't quite ready, they weren't quite ready to fix the constants. And so now, apparently, they are, so that's why this is happening now.

17:21 MC: Yeah. So, this has been an undertaking that's been going on for many years. But are there more changes on the horizon after this big one?

17:28 AC: What's next afoot is a reconsideration of the definition of a second. In principle, it will still be defined as some gigantic multiple of the oscillations of radiation from a particular atom, but just which atomic transition is used and which frequency of light is going to be changed. That may happen as soon as 2030.

17:51 MC: It's not for a little while.

17:53 AC: It's gonna be a while. But at the same time, obviously, science keeps growing, and one of the things that the folks who do this sort of work have to be open to is, of course, people invent new units. The metric system was born shortly after the French Revolution, and a committee in France got together and they defined the meter and the kilogram. But back then, those were the units. All these other things have come since then.

18:19 MC: Right. All right. Thank you so much, Adrian.

18:21 AC: My pleasure, Meagan.

18:22 MC: Adrian Cho is a staff writer at Science. You can find a link to his piece at sciencemag.org/podcasts.

18:30 SC: 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 subscribe to the show anywhere you get your podcasts, or you can listen on the Science website. That's sciencemag.org/podcasts. To place an ad on the Science Podcast, contact midroll.com. This show was produced by Sarah Crespi and Meagan Cantwell, and edited by Podigy. Jeffrey Cook composed the music. On behalf of Science Magazine and its publisher, AAAS, thanks for joining us.