

Cycadology with Dr. Nathalie Nagalingum

Ologies Podcast

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Hey, hey, it's that yogurt parfait that, honestly, could use a little more granola, Alie Ward. I'm here with an episode that took not only two years to make, COVID be damned, but has also been in the works since the Permian period, 270 million years ago, nerds. When it comes to cycads, she is it, she is the person. And wait, hold up, what is a cycad? [*whispers*] Good question.

So, with a name like cycad it could be anything; it could be a person on top and a shark on the bottom; I feel like a cycad could be a \$16 cocktail at a speakeasy full of jerks; a cycad could be a type of sore, maybe, on your mouth, if you're allergic to citrus, if I had to guess. But no, backing up. A cycad, it comes from the Greek, a typo for the word 'palm'. Despite a cycad, which is a plant, not being a palm tree at all. So, cycads have been on the scene 200 million years before palm trees. Palm trees stumble in like, "Hey, what's up, what did I miss?" And cycads are like, "What did you miss? Oh, just the rise of the dinosaurs and, like, gymnosperms, AKA plants that just bust out naked seeds without even having these new flowers, or whatever you have, palms."

So, cycads, ancient plants, so much older than palm trees and they have a stout hairy trunk. It kind of looks like if your cat used a pineapple as a scratching post. And they have a bunch of stiff, pinnate leaves, they have a spine down the center. And just like in ancient times, there are rigid females and males. They are also critically endangered. They're surrounded by so much drama, so much drama! You're not going to know what to do with yourself! Plants? Yes. Hang tight.

So, this cycad sleuth got a PhD at the University of Melbourne and continued her postdoc research at Duke, and UC Berkeley, and Harvard. She went back to Australia to be a research scientist at the Royal Botanic Garden in Sydney, and then in 2017 made the journey back up to the northern hemisphere to join the California Academy of Arts and Science in San Francisco as an associate curator and the McAllister Chair of Botany. It was there that I met her when I moderated a Women in Science panel. I remember it well, many ologites in attendance, and this ologist was someone I just adored immediately.

I met her in March of 2020, March 5th. Augh! No one was in masks, very few people had hand sanitizer, and hundreds of us packed into a room fearlessly. Instead of handshakes, we knocked sneakers in a greeting being like, "This is going to save us. We were so young; we were so naïve." Since then, I'd wanted to interview her for years, just waiting for this pandemic to be over. But you know what? Too much waiting, let's do it.

So, Nathalie spoke to me this week from Australia where she's with family. We hopped on to chat, which you're going to hear real soon, but first, a quick thank you to all patrons who support the show at [Patreon.com/Ologies](https://patreon.com/Ologies). You can join up for a dollar a month or more and submit questions. Thank you to everyone who talks to their friends and maybe their foes about *Ologies*. Thanks to everyone who makes sure they're subscribed, that really keeps us up in the charts. Also reviews do, I read each and every one of them. And to prove it, I will pick a fresh one. Thank you, LouBug19, who wrote:

For lovers and haters of science alike. I hated science in high school, like so much. Ologies makes science of all types absolutely fascinating, and I cannot get enough of it.

So, thank you, LouBug19. Everyone else who wrote a review, I read it, and I love you, thank you.

Okay, you ready? Nope. You're not. That was a trick question. Okay, here we go: plant capers, investment strategies, Jurassic flimflam, nudity... sort of, the Michael Phelps of plant sperm, neighborhood cycad safaris, cultivating pet plants, thumbs that are not green, heists, thrillers, poachers, rangers, gardens, and one of the best fixes for procrastination I have ever heard with botanist, research scientist, scholar, enthusiast of charismatic gymnosperms, and one of the world's most respected, charming, funny, and endearing scientists, the universally beloved, cycadologist, Dr. Nathalie Nagalingum.

Alie: First off, I should ask, can you say your first and last name and the pronouns you use?

Nathalie: My name is Nathalie Nagalingum, and my pronouns are she/her.

Alie: I hate to ask this because everyone asks this, but what time is it there?

Nathalie: It is 8:34.

Alie: PM?

Nathalie: AM.

Alie: AM! Oh my gosh, okay. Did we get you up early?

Nathalie: Yes, you did. I had two alarms set to make sure I wouldn't sleep in. [*Alie laughs*]

Alie: I'm sorry! We're both having our first coffee of the day, probably.

Nathalie: Yeah, I had breakfast, and yeah... made it.

Alie: Well, I'm so glad that we're finally doing this because I had such a good time talking to you in San Francisco. That was just an amazing, amazing time and I've been waiting... that was just a few days before COVID wasn't it?

Nathalie: Yeah! It was pre-COVID. I remember you tapping us with your shoes to greet us. We didn't know anything!

Alie: I feel like that was one of the last fun times in public I had, was with you.

Nathalie: That's true, yep.

Alie: I didn't know what a cycad was until I met you.

Nathalie: [*laughs*] Yeah, and they're so endangered.

Alie: And for lack of a better term, we can call you a cycadologist?

Nathalie: Yeah.

Alie: Is that a real word?

Nathalie: Yeah, it is, actually.

Alie: It is!! Yes! [*deep breath*] That makes me so happy because I do feel like we nudge toward words that are very new sometimes.

Nathalie: [*laughs*] Yeah, this is real.

Alie: These plants are so old!

Nathalie: Yeah, they're pretty ancient. If you look at all those dinosaur pictures, you're going to see something that looks like a cycad.

Alie: Were cycads around during the time of the dinosaurs? Or were *their* ancestors around?

Nathalie: That's kind of tricky. The ones that we see today are kind of like a whole new crop of species but their great-great-grandparents, they were around during the time of dinosaurs. And they also had distant relatives, cousins kind of thing, that looked like them, that were around during the time of the dinosaurs.

Alie: To me, I think of a pineapple wearing a palm tree as a hat, and I feel like that is perhaps not the best description. Can you explain what does a cycad, in your experience, look like?

Nathalie: That is a great... it's a really good description.

Alie: Really?

Nathalie: Yeah, I never thought of that, I love it. [*Alie exclaims excitedly*] I use a really boring description. I think it's the botanical description, saying it looks like a palm, it's got a stout trunk, and it's got a crown of leaves at the top. They have cones and those cones look like pinecones. But yours is much more interesting. [*Alie laughs*]

Aside: So yes, very deep green, stiff leaves, a hairy, stumpy trunk. You've seen a million of them planted in dentist's offices, and maybe malls, in business park landscaping and thought, "Wow, what a very small palm." So, people either take them for granted or are obsessed with them, for like millions of years now.

Alie: How long does it take for them to reproduce? Why are they so endangered?

Nathalie: They grow really, really slowly. So, if you think of the seed, the seed takes a year for the root to germinate, and then it's a few months after that that then you get the first leaf.

Alie: Oh wow.

Nathalie: So, that in itself is really slow. And then each cycad plant, it just grows about, I don't know, 1 cm... I'm in centimeters here... [*Alie laughs*] half an inch or something? It grows really, really slowly each year. So, if you see something that's up to your knee, that's probably about ten years old.

Alie: Oh! So, they're little guys, kind of, right?

Nathalie: Oh yeah, but if you go into the field, you can find really big guys. I've been to field sites where they're three meters tall and I've had to get my husband to, like, climb on a rock and reach on his tippy toes to get a sample for me because there's no way that I can reach it.

Alie: What does your fieldwork look like? Do you have to take a time machine, at all, to the past?

Nathalie: Oh, totally. My time machine is our car [*Alie laughs*] and what I do is I... We have all these collections, and this is common for all of biology, that we store collections of plants and animals that we've found in the wild. What I do is I look at those collections and find out where the cycad's been collected before, and I go back to those collections, and note down where they're from, and I go back to those locations and try to find them. Sometimes I can go back and there are no cycads there, sometimes I can go back and there are cycads there; it is kind of hit or miss.

Aside: So, part of Nathalie's work involves tromping through field sites, looking for new species or discerning the presence of specimens that are thought to be extinct in the wild, or she returns to field sites other botanists have documented to drop by, like a

little, “Yoo-hoo, anybody home? Just checking in.” So, cycadologists pass this baton generationally, kind of like science links in this unbroken chain.

Alie: How long have you been studying cycads?

Nathalie: So, I started off my career as a paleobotanist. Break that word down, paleo, meaning ancient and old, and botanist meaning someone who is a botanist who studies botany, plants. So, I study ancient plants. That really fascinated me, being able to go back in time. And cycads are these really, really ancient plants. So, I started studying cycads and ferns, and conifers, things like pine trees.

Then a little bit later into my career, we got the ability to use DNA to answer these ancient questions, not just through fossils. So, I transitioned into that. So, now I use DNA to try and uncover all of those questions that I was trying to answer just using fossils alone.

Alie: Oh wow! So, now you have this completely backstage, molecular way of looking at things. Whereas before, did you just have to look really closely at whatever their leaves, and their stems, and their roots looked like to try to identify them?

Nathalie: Yeah, yeah! You sort of had to group them based on those characters that you said and then were they similar to say, ones in Antarctica, were they similar to ones in Australia? Sort of just using features like that that we figured out what was happening and if there were changes over time, then you could say, “this has evolved from that,” or there has been some kind of evolution happening.

Alie: [*“Hold on, back up.”*] Did you say Antarctica? Are there cycads on Antarctica or are you... is that a joke?

Nathalie: No!

Alie: What?!

Nathalie: In the Cretaceous there were lush forests in the Antarctic. [*“This is news to me.”*] And so, I studied fossil ferns there. It’s like the last place you would believe there are ferns. What happened was that the world was much, much warmer; it was called a greenhouse Earth. So, the world was warmer and there were dinosaurs down there, there were lush forests. Those forests were actually really similar to the Australian forests and to the South American forests. So, you find things like these huge conifer trees, you find ferns, you find cycads, you find little bitty mosslike relatives. You find them all.

Alie: [*gasps*] That’s blowing my mind that underneath tons and tons of glaciers and snow are fossils of ferns and mosses and cycads... and dinosaurs?

Nathalie: Yes, yeah. [*Alie exclaims*] And the cool thing about dinosaurs from that region, Australia, Antarctica, South America, is that they had these really big eye sockets because half of the year in Antarctica, it was dark. And so, they had these huge eyes to allow them to see during the dark period.

Alie: Oh my god. Okay, did dinosaurs in Antarctica, or did dinosaurs in general, did they eat cycads? Were they edible?

Nathalie: Yes. So, over the last few years, there’s increasingly more evidence that dinosaurs ate cycads. I’m always on the lookout for papers that show evidence of this, maybe like 15 years ago, there was kind of like, “These are some leaves, it looks like they could be

cycads in a dinosaur's gut but we're not 100% sure." And then more recently we've found seeds in dinosaur guts that are definitively cycads and some leaves as well that are from dinosaurs' guts.

Alie: Oh my god. The fact that someone could look at a fossil and be able to see certain seeds that a dinosaur ate as its final meal is... bananas, or rather, cycads. But what do their seeds look like? How do you even identify a cycad seed?

Nathalie: They're just kind of a round blob really, they're not very exciting. [*Alie laughs*] They do differ, they differ by species and genus and stuff like that. They're kind of big, maybe... like the palm of your hand.

Alie: Oh really?!

Nathalie: Yeah, they're pretty, pretty big. And then some of them are probably, you know, much smaller, maybe the size of your thumb. It just depends on the species, and there's always variability.

Aside: So, reminder: cycads are gymnosperms, or naked seeds which is extremely sensual of them. And their nude seeds, they're just waiting around for pollen. Where angiosperms, *angeion* means container, so a contained seed, have much more complicated reproduction; it involves flowers and some other romantic business like encasing their seeds perhaps in a delicious, juicy ovary, AKA a fruit. But cycads, cycads are like, "No, I'm a gymnosperm. I'm here, I'm naked, let's do this." In female plants, they can just be hanging out in a feathery-looking leaf nest in the middle of their fronds. There's plenty of variability in the seeds. But from the gaze of my light googling, they kind of look like dried pinto beans or fava beans.

Alie: How did they get dispersed if they were so dang big?

Nathalie: That's another question that I think about a lot and people have done studies. So, one of my favorite studies by some people up in Queensland, is they got a cone and they put little bits of metal on them, like a nut, or a bolt, or a nail, and then they just sort of let it become ripe. And then they went around the bush with a metal detector, and they tried to figure out how far away did their seeds go? [*Alie laughs*]

So, they found that they didn't go very far. It was like little mammals, Australian marsupials, they had sort of picked apart the cone and taken them a couple of meters away, but not very far. There are also thoughts that emus eat them in western Australia, other birds might eat them like cassowaries in the north of Australia. I'm not so sure in South Africa. I don't think there is evidence of the big megafauna, the big five, eating the cycad seeds.

Aside: Okay, quick aside. She dropped "The big five" like a Los Angeles person casually talks about freeway interchanges. But I looked this up for us, and those big five animals are: kangaroos, wombats, koalas, crocodiles, and emus... Wait no, okay. Another website said: kangaroos, wombats, koalas, crocodiles, and platypuses... Shit, okay, never mind. Okay, another person lists: kangaroos, wombats, koalas, platypuses, echidnas. I don't know Australia; I don't know what your big five is! For a cane toad like me, I reckon it's a bit of a dog's breakfast. Good on me. Ta! ... I looked up slang.

Nathalie: So, basically, once you've got a cycad population, if you take it away, nothing is going to bring it back.

Alie: Oh, wow. Can you tell me a little bit about their range? Where do we find cycads now?

Nathalie: So, I like to say that they are found in regions that I like, which is warm and tropical. [Alie laughs] And so, it's great for field work, sometimes it's a bit hot and a bit mosquitoey but it's kind of like the warm tropical bands like the top of Australia, in the Pacific, in the Caribbean, in Asia, so Thailand, up into India, some in China, then you go across to Africa, and southern Africa, and Madagascar as well. So, they're sort of in a band in the middle of the globe.

Aside: So, if cycads were looking for an apartment, their search terms would be like "warm vibes, average to above average humidity, equatorial adjacent, maybe." Places like Central America or the northern parts of South America, eastern Africa, very popular region, and the coasts of Southeast Asia. But what about Nathalie herself, was it always locations, locations, locations?

Alie: Did you grow up wanting to travel a lot? Did you grow up really curious about native habitats? How did you end up getting to travel around and learn so much about these very endangered, beautiful plants?

Nathalie: I had no idea that I could have a job like this. I'm a first generation, my parents are from Mauritius, which is a tiny little island next to Madagascar. Not many people have even heard of it. Actually, people probably know it because of the dodo; that's where the dodo was from, and the dodo became extinct there. But otherwise, people don't know about it.

So, my parents moved from Mauritius to Australia, and we were encouraged to go to school and, you know, "We came here to give you a better life." So I went to school, I went to university, and I just sort of kept following what really interested me, and that was science. And then I didn't realize that I could be a doctor and pursue these plants all over the world.

Alie: What was it like when you got your doctorate?

Nathalie: It was just relief because it was a long time. [both laugh] I think once you do it, it's just... for me and I think for many people, I just felt sick of it. It was like, "I just want to get rid of this, I want to do something else," because it just consumes your life. So, I was just happy to get it done. I think the nicest part was, my family was so happy. And so, I have photos of my graduation day, and everyone was so pleased, we were all smiling. So, that was really nice.

Aside: So, Dr. Nagalingum has published papers with titles like, "Conservation genetics of wild populations and botanic garden collections of Australian cycads." And "Phylogeny of the gymnosperm genus *Cycas* L. (Cycadaceae) as inferred from plastid and nuclear loci based on large-scale sampling: Evolutionary relationships and taxonomical implications." But what plant knowledge is she just, really digging into now?

Alie: Is there anything that you are really excited about researching right now?

Nathalie: Yeah so, this project is basically like a zoo breeding program. Now we have all these zoos with lizards or frogs, and we found a population and we use their pedigrees to figure out which ones we're going to breed together to make sure that we're not inbreeding, and we increase their populations for eventually bringing them out in the wild. So, we're doing that for the cycads.

We are doing it for maybe about 10 species that are pretty much extinct in the wild. We've got samples from private collectors, from botanic gardens, and we've figured out the DNA profile of each of those samples. What we're doing is we're going to determine, first, are they clones of each other? Because that's a thing that cycads do, they can produce clones. And so, we don't want to have a botanic garden full of 20 clones. In the long term, once they grow big enough to breed, we want to breed them and produce more plants to increase that population and increase the health. So, we're going to use genetics to help guide our breeding program. So, just like a captive breeding program in a zoo. So, I've got someone working on that and she's doing an amazing job.

Alie: Has there been a moment where you realize something, either with DNA or through fossils, that you realize you might be one of the only people to know that?

Nathalie: There's a few instances where three subspecies were sort of lumped together and then looking at them with the DNA it was like, "No, these are two subspecies and one of the subspecies is an entirely new species." [Alie gasps] That's with DNA. And it's not been done quite a lot in the cycad world, yet. Most of the time... I'll just take a little segue. Most of the time it's the cycadologist going into areas that we haven't explored and finding new species with these really obvious characteristics.

The other thing I found really surprising is when I was looking at the DNA of today's cycads, I expected them all to reveal that they all evolved alongside the dinosaurs and they were just, sort of like, hangers-on and made it up until today. But then if you think the dinosaurs died out 65 million years ago, my DNA patterns were showing pretty much all of these cycads evolved 12 million years ago, so there's no way that these species today lived alongside the dinosaurs. And so, really sort of reframes it because if we think of how endangered cycads are, then they haven't survived all of these millions of years of global changes, pressures from dinosaurs. They actually adapted to modern conditions. And so, they may not have the abilities to survive things like global warming and climate change.

Aside: So yes, while cycads were here for much longer before many other modern plants, like these newbie palms, and flowers, and fruits, maybe that pear in your lunch, it doesn't mean that cycads stopped growing, or stopped evolving, or stopped doing the work this entire time. Which means that in the Anthropocene, this time, they're vulnerable, because of us. And cycads, I'm so sorry. That sucks and you deserve better.

Nathalie: There's one species, it's called *Encephalartos woodii*, that was found in South Africa as a clump of four stems and because the plants are either male or female, that clump was only four males. ["Hey, what's up dudes?"] So of course, being Victorians, they just dug them all out and put them in various botanic gardens. So now, they've never found a female and there's only the males, and they're all around the world. They've produced clones everywhere, but it's never going to reproduce, it's just this one plant.

Alie: It's like that tortoise in the Galapagos, George, the loneliest turtle.

Nathalie: Yesss! Lonesome George, yeah.

Alie: Yes! Oh my gosh. I wonder if one day they're going to find a female somewhere, some old, ancient, in some forest or some overlooked bush.

Aside: But it's not just sudden climate change that's affecting their population numbers. No, no, no, no, no. Stretch your thumbs, because you're about to text some really weird shit to your entire address book. Get the family chat ready for this.

Alie: And one of the reasons why they are extinct is partly collecting and trafficking, is that right?

Nathalie: Yeah, it's crazy. People are astonished when they find that out.

Alie: I can't believe it. When I first interviewed you... and I'm still... like, the *drama* of a cycad. What's happening out there?

Nathalie: It's crazy. I remember a ranger... when I worked at the botanic garden in Sydney. It was like, "Hold on, they got stolen?" Because I had some specimens stolen from me. And it was like, "But they're not diamonds. Why are they stealing them?"

Aside: Okay, let's get into it, who are these plant thieves?

Nathalie: People are so obsessed with cycads that they want every single species, and there are about 350 species. We're still finding more. So, they want every single species so they will go to all lengths to poach them. [*"Gotta catch them alllll."*] There are stories of people who have dynamited cliff faces to get the cycads out. At the botanic garden in Cape Town, what they have done is gone in in the middle of the night and purposely dug up specific species and taken loads out. It's not like the cycad garden is on the edge of the garden; it's really deeply into the garden. And so, these poachers know exactly what species they're targeting, and you just see empty holes where they've taken those particular species.

Alie: It's like the worst kind of gophers ever, human gophers!

Nathalie: Well, I wouldn't even say gophers. They're just criminals.

Alie: Yes, that's a better way of putting it. So, how much are they worth when they're getting them?

Nathalie: Some could be like 30,000, 40,000.

Alie: [*gasps*] Whaaatt?! I'm sorry, that's so loud, I'm so sorry! [*both laugh*] Are you kidding me, worth more than a car?

Nathalie: Oh yeah! If it's super rare... like someone told me there was this huge species that is now extinct in the wild, and we saw it in a private collection in South Africa, it probably went up to your roof. He said to me, it's probably worth a million dollars. [*Alie shrieks*]

Aside: I am losing my shit. Are you losing your shit? I'm losing it. That's bananas!

Nathalie: And the other thing is people in South Africa, what they do is they'll buy a rare species for their kid when their kid is young, raise that species, and then by the time that kid is old enough to go to college, they will sell it and they'll have the money to... [*laughs*]

Alie: No. Oh my god! Cycads are Bitcoin? [*Nathalie laughs*] What's happening?! What is the world? So, cycadologists, do y'all... are you all on a WhatsApp thread talking about this kind of stuff? What happens when you meet up in person, what are your Zooms like?

Nathalie: So, what we're focusing on is trying to figure out ways to stop this kind of thing from happening. There's different ways; there's national parks. You know how you have rangers guarding rhinos and elephants, they walk around with them.

Aside: So, I was not aware of this, but in countries all over the world with critically endangered species like the black rhino or African elephants, armed rangers patrol for poachers. These units can range from pretty ruthless, for example, Kaziranga Park in India sees more poacher deaths than rhino killings, that's all over the news. There's also

really progressive movements, like the International Anti-Poaching Foundation's squad of all-vegan women who are rangers in Zimbabwe.

And a 2021 paper I found titled, "Poaching of *Encephalartos transvenosus*, in the Limpopo Province, South Africa," agreed that "Patrolling and law enforcement seems to be the agreed means by which poaching can be addressed as indicated by all the respondents from the three nature reserves." Oh, and that last paper, *Encephalartos transvenosus*, that's a cycad. So, in South Africa, 3 of their 38 native species are what *Africa Geographic Magazine* called, "Loved to death," or "extinct in the wild." 3 out of 38 already.

Nathalie: There's rangers who do that for cycads. So, that's one way to deal with them, and they've actually shot people.

Alie: Really! People trying to steal them? And they're like, "Get out of here."

Nathalie: Yeah, and they've shot them. People have gone to jail.

Alie: My god! Why aren't there more thrillers about this?

Nathalie: There should be, shouldn't there?

Alie: Where is Liam Neeson, where is his cycad movie? [*clip of Liam Neeson in Taken, "But what I do have are a very particular set of skills."*]

Nathalie: That would be a good move actually.

Alie: It would be a good movie. Okay, I think you're an EP on it, obviously. [*Nathalie laughs*] I'll be a PA on set who runs around and gets everyone's coffee just so I can hang out with you and learn all this stuff. Do you ever have to, like, testify or be like an expert about any of this kind of stuff?

Nathalie: No, no. Thankfully no. In the US there isn't any native cycads, except maybe in Florida there's a few and they're really, really common. But people I know in South Africa, yeah, they have had to go to court and testify.

Aside: So, if botanical burglary drama is what you're after, just google word pairings like, 'cycad heist' or 'plant poacher'. The internet will haul up just a wheelbarrow full of returns from a 2001 Department of Justice memo, elaborating in detail about five individuals who sent approximately half a million dollars' worth of protected cycads to the US from South Africa, Australia, and Zimbabwe, and then another criminal, who bought them. That criminal's name was Donald Wiener, he bought \$200,000 worth of stolen plants in the year 2000! That's so many dollars of plants.

There's also this South African power cycad couple; they each ran their own flourishing businesses buying, selling, and dealing cycads, until greed and deceit, gambling and poaching ripped them apart. Anyway, it's thrilling, it's gripping; welcome to the world of cycad drama.

But we're about to get to your questions with Dr. Nagalingum, but first we like to donate to a charity of the ologist's choosing and this week we're honored to donate to Ovarian Cancer Australia in Nathalie's name. She has a personal connection to them and if this cause means something to you or if you'd like to thank Nathalie for her work, consider donating to them on February 23rd as gifts will be matched that day. So many symptoms of ovarian cancer could be overlooked like bloating, and fullness after meals,

and abdominal pain, and it gets overlooked a lot. You can find out more and you can donate if you'd like at OvarianCancer.net.au. There will be a link in the show notes.

While you're at it, you can find Nathalie on Twitter, tell her how much you appreciate her. Her Twitter is @NNagalingam and will be linked in the show notes. So, thank you Nathalie for telling us about that, and thanks to sponsors of the show for making that possible.

[Ad Break]

All right, let's get to the root of your questions my fronds.

Alie: Okay. Listeners, they know you're on, they're excited. Aki wants to know: I hear these plants can host many things. What are some of the most unusual things that have been found in cycads?

Nathalie: Oh, gosh there's so many. In their roots, they have a bacteria, and that bacteria gets nitrogen from the air and converts it into a usable nitrogen for the cycads.

Aside: So, these roots, side note, are called coralloid roots and I just fell down a musky tunnel about them. But the short version is that they're these knobby roots of cycads that hang out in the shallow layer of soil and they grab tiny cyanobacteria that photosynthesize, and they recruit them! The cyanobacteria are like, "Okay, okay, I can fix nitrogen for you. What's in it for me?" And the cycad roots are like, "Sugar, carbs, all the sweet yums you want for that nitrogen". So, the cyanobacteria are like, "All right, I'm in."

Now, if you were to cut a coralloid root, you would see that green cyanobacterial zone as a ring inside of it. So, cycads: ancient living soap operas in just a dirty, modern world. We love 'em, but let's not love 'em to death. You know who else loves them? Bugs.

First-time question-askers, Noah Siem and Jacob Bowman, both asked about beetles. In Noah's words: Is it true that cycads are pollinated by beetles because they existed before bees evolved? And yes! I looked it up. Bees have only existed for 130 million years. They were coming on the scene while cycads were in middle age and beetles were like, "Oh hey, what's up? Bee? Cool... that's cool." Other pollinator questions came from listeners Harper Thomas, Floridian Gerald Thompson, and Anthony, who asked: If I'm not allowed to be their personal pollinator, then who is?

Nathalie: The pollinators, they host their pollinators inside the cones. Pollination is one of my favorite stories because you have cycads and the plants look exactly the same, you have male and female plants. But once they produce cones, then you can say, "Oh, this is a male one, it produces pollen. This is a female one, it produces ovules," which eventually produces eggs.

And then, you need the beetles to go to the male ones, and what they do is they get attracted by this odor that the male pollen cones emit. It's a slight odor, or technically it's a volatile. So, it attracts all of the beetles, and there's also thrips as well, and weevils, and they... basically, it's an orgy. They feed, and they mate, and they lay their eggs on there. So, they have an orgy on the male pollen cone and then, once, I don't know how the pollen cone decides but it decides that "Okay, you guys have had enough, I need to kick you out." [Alie gasps] So, what it does is it increases the amount of the odor, and it kicks them all out of the cone. [*"I think you should leave."*]

And it's kind of like, it's like when you wear cologne, you know if you wear a little bit of cologne, that's really nice. [Alie laughs] And then if you wear a lot of cologne... you know when you're stuck next to that person who's got a lot of cologne on and you're like, "Oh my god you're stinky." [Alie still laughing]

Alie: Oh, my god.

Nathalie: Yes, so they get rid of them. The cool thing about that is it's possibly the only plant system that does that. If you think about others, like flowers, they will attract insects with their odors to pull them in, but they don't actively push them away with their increased cologne. So, that's a really unique system, and considering that these are pretty ancient, they've still got this very modern, interesting system that nothing else has developed.

Alie: That's pretty sophisticated.

Nathalie: It is, it is. And there's somebody out of Utah and she's been working on this a lot as well. She has some really cool work, Irene Terry. So then, after that, the insects get kicked out because of all the cologne, and then they go to the female cone that produces a tiny little bit of odor, enough for the insects to come over. They crawl all over and they pollinate the eggs and then they leave.

Alie: Wow. That's so cunning... it's coning, it's cunning. [Nathalie laughs]

Aside: Okay, so when Nathalie describes this as a cologne dose gone wrong, she's not kidding. This species of cycad makes a compound called β -Myrcene, to seduce these tiny little insects called thrips. Now, how does it blast them away? How does it suddenly squirt a bunch more cologne? The cycad uses its stored carbohydrates and fats, and it burns them all to raise its own temperature during the hottest part of the day, which lets off more of this Beta-Myrcene. So, the now-pollen-doused thrips are like, "We're out," and then they go find a less-stinky female plant, dusting it with the cycad sperm. So, who needs flowers, when you have strategy people and β -Myrcene?

I wondered what that was and what it smells like. What do they smell like? So, I googled the work of Dr. Irene Terry, who Nathalie just mentioned, and in a 2007 *New Scientist* article titled, "Ancient plant has hot, stinky sex," Dr. Terry stated that the whiff, "Takes your breath away. It's a harsh, overwhelming odor, like nothing you've ever smelled before." But what does that mean? Dr. Terry! Come on! To her credit, Dr. Terry is not one of those perfume guys on TikTok.

But it turns out that β -Myrcene is used in perfumes! So, I asked some cologne and fragrance websites which used terms like fruity, fresh, and clove-like. The Good Scents Company website used the most adjectives including spicey, earthy, and musky, refreshing, almost citrusy, but warm-balsamic and ethereal-sweet. Mmm, I want to be doused in the lovemaking of a cycad. But trust a thrip people, too much of this compound can be irritating and toxic. So, even if you're enjoying the plant jizz, you're going to want to bounce too. On that note...

Alie: One listener wrote in, Karla Maria Pires, and asked: WHAT?!?! Cycads have motile sperm cells?!?!? Tell me more! Is that true?

Nathalie: Yes, so the sperm in cycads has motile sperm cells.

Alie: So, they are swimming around?

Nathalie: Yeah, they do swim around, yeah. They're like a little blob and there's like a helix of little tails, like flagella, that go all the way to the top. You know, like a spinning top. And then at the top of the pointy bit you've got all those flagella and then the flagellae sort of wind their way around and it helps them swim.

Alie: Wow. So many advancements. They really have a lot of bells and whistles, you know?

Nathalie: Yeah, and that's something to be cautious about. When you talk about something that's really ancient, it may not be ancient in all its ways. So, using the term like "living fossil," which I have done, it's kind of a misnomer because we're kind of just saying, it's old it hasn't changed. But it's still had millions of years to change, and it's got some cool features.

Alie: Well, Zoe Armistead, first-time question-asker, asked how someone who is not a cycadologist, someone who is not a Nathalie, can tell the difference between male and female cycad plants? Zoe says: They kind of look like they have giant wangs. So yeah, any thoughts on that?

Nathalie: Yeah, so the pollen cones... If you look underneath each individual unit, we call them scales, you'll find little balls underneath them, which is funny considering [*Alie laughs*] we're calling them wangs. They're tiny, tiny little balls, and that's where the pollen comes out. It's only when you can see the cones.

Aside: So, look for round spherical objects on the underside and a conical pollen phallus in the center... It's a boy!

Nathalie: And then there's a few different kinds of female cones. The one that's the sago palm, it just looks like, almost like an open bud flower, but it's not a flower. And you can see the seeds as they mature under the edges of the leaves. Otherwise, they just look like big pineapples, like you said. They're a bit more tricky to tell apart. But the telltale one is the little balls on the scales.

Alie: There's going to be people who are in a botanical garden, looking at cycads and they'll probably have a security guard being like, "Why are they so close up in there? Why are they in the undercarriage? Get out of their junk!"

Aside: But a word of warning...

Nathalie: The pollen has neurotoxins in it. [*Alie gasps*] So, just be careful not to breathe them in. I mean, I don't know, you'd probably really have to snuff them in but just be careful and wash your hands.

Alie: Have you ever had to worry about that when you've been out in the field?

Nathalie: Not out in the field. But definitely... like I've tried experiments where we get pollen, and we do artificial pollination. So, we get the pollen, and we wear masks, like we're all wearing masks now, so you get like N95 masks, which we all know now, just to make sure we're not breathing in that pollen.

Aside: Prehistoric, poaching, plotting, poison, nude seeds! Cycads, you are the forbidden reality show that we did not know that we loved.

Now, who else asked about toxicity? So many of you including Kairsti, first-time question-asker, Matt Jollif, MB, and...

Alie: We actually had a few listeners write in to say, Kelly Shaver wants to know: What is with this thing where animals eat toxic cycads and they're fine, but humans eat the

animals and are affected by the toxins? And Emma Garsch-a-gen wants to know about poison seeds, if that's true of all cycads.

Nathalie: Yes. So, they are poisonous and the toxins... the toxins are pretty bad. So, one story that I can think of is in Guam where... it's actually not conclusive but they thought that people who were eating the seeds of one of the Guam cycads during the war, either they didn't prepare the seeds properly and just ate them without preparation and they got sick, or they were eating fruit bats that were able to withstand it and they got sick from that. They ended up with a neurological disease, like an ALS, Parkinson's-like disease, which coincidentally, after the Second World War, when the food shortages ended, incidents of those diseases ended.

But there's still a big scientific debate about why this is happening, kind of thing. I don't really know why they're toxic to us but not to some animals. I mean, some cows, I think the Australian farmers call it "dropsy" or something, they get paralysis in their legs sometimes if they eat cycad leaves. And sort of all around the world... what I love is that peoples all around the world, in Australia, Guatemala, Mexico, South Africa, people have figured out how to detoxify the seeds. So, they figured out you can use ash, you can put them in a basket and run that basket through a creek and it leaches out all the toxins, or through a series of soaks. So, this is a kind of funny one where they soak them in a series of soaks, and they decide whether the toxins are leached out by giving some water to the chickens. And if the chickens die, then the toxins have not been eliminated so they keep going with the soaks.

Aside: Okay, so I tried to find out whether you can eat a poisoned chicken. But after learning that the sago palm is extremely poisonous to animals, including humans, and that pets think it's delicious but within 12 hours of eating it, they can develop vomiting, diarrhea, weakness, seizures, liver failure, bruising, nosebleeds, and blood in the stool, and that the ASPCA Animal Poison Control Center, estimates a fatality rate of 50-75% when ingestion of the sago palm is involved. I'm like, I don't think anyone wants to eat those chickens. I think they're like, "Cacciatore?" And everyone's like, "Absolutely not. No. Toss it in the river."

Alie: Getting back a little bit to that toxicity, NanoNaturalist asked about the Oliver Sacks book, *Island of the Colorblind*. Have you read that at all?

Nathalie: Yes.

Alie: Tell me more about how you felt about that.

Nathalie: So, Oliver Sacks, his writing is beautiful. He believes that it was the bat theory, I think. And that's about Guam and that whole process of people not getting enough food and then using the cycads as a source of food. So, he and another doctor went and investigated that and said that was his conclusion, that it was the cycads that caused it. But other doctors have come up with other reasons and there's been other incidences in Japan as well. So, it's not clear, nobody really knows.

Aside: Just a shoutout to listener Bálint Novák, who is also excited about this question and asked if researchers had yet confirmed the cause of this condition, which is referred to as ALS-PDC or Lytigo-bodig disease. Essentially, a recent 2021 paper seemed to reiterate the hypothesis that traditional methods for safe consumption of cycad seeds appear to have been lost over the course of time since colonizers banned

consumption. Other articles have tracked the incidence rates, and the cycad seed hypothesis essentially seems to be going strong.

Also, I started reading yet another bananas article about a cycad caper which led with, “Joanne Flack is on the run, suspected of stealing a rare African plant thought to be extinct and worth millions of dollars. Sonja Kurtz was hired by the CIA to hunt down Joanne, to find the link between the missing plant and a terrorist group hiding out in South Africa,” before I realized that this article was a book review, for the 2020 novel, *Last Survivor* by Tony Park. I don’t know if this book is a good book, but it is about cycads and it exists, in case that kind of action thriller is just what the doctor ordered. Oh, which brings me to...

Alie: Rachel Walwood wanted to know, first-time question-asker, says: This seems like a type of plant that would be excellent for research into practical application as medicine. Yes/no/maybe?

Nathalie: Yes. In South Africa they do use the bark for headaches, they do use it for... actually some for voodoo as well. If you put some under your bed, it protects you. But that’s all I know.

Alie: I’ve got to say, if you put a \$40,000 plant under your pillow, seems like pretty good luck to me. *[both laugh]*

Nathalie: I think it’s just a little bit of bark.

Alie: Just a little bark, okay. Kitty Bailey, also first-time question-asker, wants to know if they have any appearances in mythology or any interesting stories about them? And if not, if there’s any in movies or TV that you, as a cycadologist, have seen and said, “That’s not right!” Or “Oh, they got it right.”

Nathalie: So, definitely *Jurassic Park*, they’re in there. I’m not really sure about... the mythology is pretty varied. One of the stories I love is in Vanuatu. It’s a symbol of war versus peace and it’s also a symbol of the chief. So, if you have two cycad fronds and they’re crossed, that means that the two neighboring tribes are at war. It’s only until that is resolved that the fronds get uncrossed and then they have a huge, big party.

Alie: Oh wow.

Nathalie: So, it’s also a taboo. If someone places cycad fronds somewhere, it means that this, say this person’s shop is under taboo, and so people won’t go in that shop. It’s also a chiefly symbol and if a chief places a cycad frond on the beach, he’s indicating that “This is my beach, nobody can come here.”

Aside: Nathalie also related a story about Prince Charles being gifted a ceremonial cycad frond to honor his power as a chief and warned me before googling...

Nathalie: He’s topless though so, I will just warn you about that.

Aside: Okay, so I looked around for this and I did find some pictures of Prince Charles, fully clothed in like a rumpled suit on a beach during this exchange. But the search of him topless did return some beach frolicking recon on that trip. All I can say is that I hope that his royal aides had some sunscreen in like a fire extinguisher canister, just blast it.

Now, what if it’s not enough to take home all of this knowledge? What if you want to take home a cycad? Listeners Andie, Christi Kazakov, Jenn ‘Squirrel’ Alvarez, Joe

Mueller, and Caitlyn Powell asked about their cultivation, and in Rebekah Weinzetl's words: Can I grow one in a pot in my midwestern apartment? And on that note, patrons Chelsea & Emily Davis wrote in: Not a question but, heck yeah dinosaur plants!

Alie: How do you feel about people who grow cycads and cultivate them just to keep them around? Do you feel like it's like... maybe only where they should already be growing? Or how do you feel about people propagating them?

Nathalie: Oh, I love them. I mean, you can get cycads everywhere. I remember seeing them at a Whole Foods once, someone's told me they saw them at Ikea, I've seen them at Disneyland. The common species are not hard to find and so you can easily find cycads. It's just those rare species where you're spending thousands that you know may be kind of dodgy. I love that people grow cycads and I love that people who have just been to my talks, they come up to me and say, "I found a cycad on my walk!" And they'll show me a picture of the cycad. So, they become cycad spotters. And for me, that's really exciting because now they know about them.

Alie: Yeah! And I understand, you don't have the greenest thumb... [*Alie laughs*] You told me when we met in San Francisco that you're like, "I actually am terrible with plants."

Nathalie: Yeah, can't grow anything.

Alie: [*laughs*] Which makes me feel so much better because I am not good with plants, and I kill every cactus I've ever had. Any tips on how to cultivate a cycad? Do they like sun? Do they like Miracle-Gro?

Nathalie: I don't know. [*Alie laughs*] I feel like this is a really mean question, Alie. [*Alie laughs*] You know I don't know how to grow plants.

Alie: [*through continued laughter*] It's one of the reasons I fell in love with you. I was like, "I love that this is a botanist who is like, 'I'm not very good with plants.'" But you are good with plants on a level that's like, saving them, and like a molecular and taxonomic and like, going around the world. Doesn't mean that you have to be good at growing one in a pot on your desk. [*laughs*]

Nathalie: No, no, no. I'll leave that to experts.

Alie: I feel a kinship with you.

What about the hardest part of your job, other than growing plants?

Nathalie: I mean, it's just like, there's writing papers and that pressure of writing papers, that's hard. And I think a lot of academics would say that. It has to be really good. There's that constant churning out of papers as well that... you don't want to write rubbish and so it's hard.

Alie: Are you someone who writes a lot of drafts or someone who just wrings your hands, procrastinates and does it all at once? What's your strategy there? Any tips?

Nathalie: The way I do it is that I will set it aside a time, in the morning usually, and I will just sit at my computer and force myself to write one or two paragraphs. In my mind I'm like, "This is really crap but I'm just going to write it." And then I'm going to do whatever I can and the next day I get back to it and I fix that one, and I write another one, and I sort of keep going that way. I can't do the whole thing in one; it's just little by little.

Alie: That is really, really good advice, to revise what you've done and then do a draft that you allow to be rubbish. And it's never that crappy, is it? When you go back, aren't you like, "Hey, this is pretty good!"

Nathalie: Yeah, I mean the ideas are there, you just sort of restructure it and fit it in with the next paragraph. And you know, the hard part is starting.

Alie: Augh, tell me about it, man. That's great advice, you may have just changed people's lives with that relay writing where you're like, "All right, fixed the last one, do the next one." That's great. I'm going to try that.

What about your favorite thing about cycads or your work?

Nathalie: I love talking about cycads because they're so fascinating. I mean, I've told you a little bit about them but there's so many more things that I could talk about. They're just fascinating. One little group of plants has so many stories. I had some dreams of writing a book about cycads and all their crazy stories about the people, and their biology, and reproduction, but never got around to it.

Alie: Meanwhile, we have this. Anything that you would recommend people look into if they're now suddenly a cycad spotter?

Nathalie: There's lots of pictures online. But the Academy has produced a bunch of videos where I'm talking about all these different issues. So if people want to hear more of my voice, you can go to the Academy's video pages and look up "Natalie Nagalingum" and watch those.

Alie: Including getting to ask you a bunch of questions at the dawn of COVID. [*both laugh*] This has just been such a joy. You've been on my list for so long and I'm glad we didn't put it off anymore, just went for it, because I wanted to ask you about this literally since the day I met you, two years ago.

Nathalie: Oh, thank you.

Alie: Thank you for the excellent, excellent work you do.

Nathalie: Thank you for having me.

So, ask iconic people, botanic questions. And let this be a lesson, when you have a friend you want to chat with, do it sooner rather than later. Dr. Nathalie Nagalingum, we straight up love you so much and you're a treasure in this world. Thank you on behalf of every cycad on the planet for your work. Nathalie's website is linked in the show notes if you want to find out more about her and her work, as is her Twitter, [@NNagalingam](#). We will also link some other videos that she's been in through the California Academy of Sciences. Also, mark your calendar for March 3rd, I'm going to be moderating another panel with them and it is part online, part in-person, but March 3rd, tune in, California Academy of Sciences. I'm really, really excited to be back in person, even if it's in a limited group. But again, follow Nathalie [@NNagalingam](#) on Twitter, tell her how cool she is. More links, including one to donate to Ovarian Cancer Australia on February 23rd, matching day, are all up at [AlieWard.com/Ologies/Cycadology](#), linked that in the show notes.

We are @Ologies on [Twitter](#) and [Instagram](#), I'm [@AlieWard](#) on [both](#). Thank you, Erin Talbert, for managing the *Ologies* Podcast [Facebook group](#). Thank you, Shannon and Boni of the comedy podcast, *You Are That*, for helping out too. Thank you, Susan Hale, who handles everything from payroll to merch. Thank you, Noel Dilworth, who helps schedule and run behind the scenes. Emily

White makes our professional transcripts, Caleb Patton bleeps them. Those are up for free for anyone who needs them at AlieWard.com/Ologies/Extras. All our episodes are also arranged by topic too on my site at AlieWard.com/Ologies-By-Topic, so you can find all sorts of episodes maybe you've overlooked. Kelly Dwyer updates the website, she can make yours too, her link is in the show notes.

Every two weeks a new *Smologies* episode comes out and those are shorter, condensed, they are de-filthed digests for all ages, totally parent and classroom-friendly and those are in your feed or at AlieWard.com/Smologies. Thank you, Zeke Rodrigues Thomas of Mindjam Media, for heading those up and Steven Ray Morris who helps too. As we record this at 9:48 PM on Valentine's Day, thank you to lead editor Jarrett Sleeper of Mindjam for making sure this gets out the door every week. Jarrett, the mayor of babe town, Sleeper, the best. Nick Thorburn made the music, and he is in a very good band called Islands.

If you stick around until the end of the episode, I tell you a secret. This week's secret is, I swear ADHD is coming out this week, I swear. Y'all, I added two more guests for it. I'm sorry, I can't help it, it's such a big episode. So, there's now four guests for it in a two-parter, it's going to be so good. I will be making some of it on a plane this week. Take care of yourself. I love you all very much, especially you, Dr. Nagalingum. And Jarrett, happy Valentine's Day. Okay, berbye.

Transcribed by Aveline Malek at TheWordary.com

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