

## **Sidedoor Season 4, Episode 10: This Episode Smells**

[Intro Music]

Lizzie Peabody: This is Sidedoor, a Podcast from the Smithsonian with Support from PRX. I'm Lizzie Peabody.

[MUSIC]

Lizzie Peabody: Sissel Tolaas is a professional smeller.

Sissel Tolass: I've learned how to turn on and off my nose and uh, and I train my nose every morning, the way I train other organs and other sensors properly.

Lizzie Peabody: Sissel is a Berlin-based artist and scent-evangelist. Her morning routine includes smelling a wide array of scents in her lab, to keep her nose sharp. She spends a lot of time traveling the world for her work.

Sissel Tolass: I just come back from the Mayan jungle in Mexico. I've been there for 10 days, doing research on the middle of the jungle. When I'm in the field, I get dirty.

Lizzie Peabody: Some people bring souvenirs home from their work trips, Sissel brings smells.

Sissel Tolass: Not only my, my body, but my clothes, my luggage are still carrying uh, you know, traces from the field work I've been doing for 10 days. And I don't clean it that quick because as part of the process of understanding where I've just been.

Lizzie Peabody: Sissel primarily devotes her nose to art, and her work has been displayed at museums around the world and at the 2012 London Olympics. Sissel says she's not part bloodhound. People are just way better sniffers than we realize.

Sissel Tolass: So, we tend to kind of leave out smells. We don't sit around the dinner table, speak about each other's smell. We speak about how we look like, yeah? And, you know, we are missing out on lots of important information by not engaging with the world by using the other senses properly.

Lizzie Peabody: But a world filled with scents is also a world filled with emotion. I remember in the summers, my favorite babysitter used to come and live with my family. After she left, I'd go into her bedroom and bury my face in her pillow because it smelled like her, and just miss her so much. I still think of her when I smell Herbal Essences shampoo. Scent binds us to memories of people and places.

[MUSIC]

Sissel Tolass: So, what makes us human is that we have emotions and the sense of smell is the biggest trigger of emotion. And I think that's a very strong argument in favor for taking smells a little bit more serious.

[MUSIC]

Lizzie Peabody: The challenge with smell, is that it's hard to preserve. Within a few days of her leaving, the scent of my babysitter would disappear. Pictures, and even sounds are easier to hang on to. I can find images of Napoleon Bonaparte, or a T-rex, or the South Pole, but I don't know what they smell like. But Sissel is trying to capture snapshots with scent.

Sissel Tolass: I catch the moment of a smell and the next moment it's gone, you know, so all my work is about this. You know, I conserve a moment as nanosecond of a smell because at the next moment it's changed already because it's influenced by other molecules. So, in, in general, my whole work (laughs) is about extinction, you know.

Lizzie Peabody: Sissel says that smell is so fleeting, that it's impossible to know what something smelled like a century, or even fifteen minutes ago. But what if you could smell Napoleon, or T-rex breath? Or, even better, because neither of those things would smell very good, what if you could bring back the smell of an extinct flower? And is it even possible? Those are the questions one biologist has spent years of her life trying to figure out. And the result is being showcased in a Smithsonian exhibition.

Lizzie Peabody: So this time on Sidedoor, what happens when a smell goes extinct? And what does it mean to bring it back? All of that, right after a quick break.

[MUSIC]

Lizzie Peabody: Christina Agapakis' curiosity about the smell of extinct flowers started about five years ago at work with some colleagues. The conversation was about extinction, and the information that's lost: the colors, the flavors and, of course, the smells.

Christina Agapakis: And we thought about Jurassic Park and, and extinct flowers. Um, you can never smell extinct flowers. They're totally gone. There's no trace of them, uh, except for their DNA, uh, that we might be able to recapture and, and draw from to, to recreate the smell.

Lizzie Peabody: In most offices, this watercooler conversation of, "What if we could bring back the scent of an extinct flower?" ends with three people shrugging and saying "Yeah. That would be neat." But at Agapakis' office, these types of big questions have a way of sticking around. She works at a company called Ginkgo Bioworks, where Agapakis is a synthetic biologist. Naturally my first question: what exactly is synthetic biology?

Christina Agapakis: Synthetic biology is what synthetic biologists do. (laughs)

Lizzie Peabody: (laughing) That was easy.

Christina Agapakis: Uh, yeah! That's the easiest way to describe it. I think the second most easy way to describe it as is, is a sort of community of people who are engineers working with biologists and biologists trying to engineer living things.

Lizzie Peabody: It's this sort of science meets science-fiction field of biology where people like Agapakis think of ways to engineer organisms. Most of the time, Ginkgo Bioworks' research is focused on things like finding the next generation of antibiotics, using live microbes as medicine, or developing animal meat-free proteins. It's work that feels futuristic and can even seem controversial. As a break from making all of the kinds of things that we will someday need; Christina applied her brain to something we didn't even know we wanted: a way to peek into the past to experience something like the smell of a flower that has been lost forever. She couldn't let it go. But the thing about extinct plants, they're extinct. Where do you find one?

[MUSIC]

Christina Agapakis: So, actually, it took quite a while to find extinct plants. (laughs) And we actually stumbled upon a paper that described a new field called museumomics.

Lizzie Peabody: Museumomics. Basically, this idea that deep inside museum collections, there's important biological information that we could put to use.

Christina Agapakis: We were able to reach out and collaborate with the Harvard Herbarium and, and search and find, uh, extinct specimens there.

Lizzie Peabody: So, Christina turned to the ultimate authority on everything.

Christina Agapakis: We printed out the list from Wikipedia of extinct plants, which had, I think there's about 125.

Lizzie Peabody: A key detail is that they were looking for plants that had gone extinct in modern times, killed by people. Plants that went extinct thousands of years ago might not have intact DNA, and they certainly wouldn't be sitting in a cabinet at Harvard.

[MUSIC]

Lizzie Peabody: What did the Harvard Herbarium smell like?

Christina Agapakis: Whew. There's huge cabinets that are full of these, like, folders, um, these dried and preserved specimens and, and old preservation techniques had all sorts of weird chemicals and that are sort of like the, it's the combination of the paper and the preservatives and the kind of, yeah; like kind of a library really.

Lizzie Peabody: But unlike a typical library, the Harvard Herbarium isn't exactly set up for this type of research.

Christina Agapakis: There's no digital collection (laughs). There's no like, digital database of what's in the Herbarium. We sort of just like went room by room looking in each of the cabinets, and sort of scanning through the folders by hand, like they're hand written in pencil, the names of the specimens on each of them.

Lizzie Peabody: And this is where Christina Agapakis first met the falls of the Ohio scurfpea.

[MUSIC]

Lizzie Peabody: Here's a quick intro to the scurfpea. It's a legume, like beans, peas and lentils. There are other scurfpeas that still exist, but this scurfpea was known to live on one small rocky island in the middle of the Ohio River, where it flows past Louisville. The last time it was spotted alive was way back in 1881.

Christina Agapakis: And then, by the early 1900s, I think in the 1920s, they built a dam on the river and actually flooded the island completely. So, that island doesn't even exist anymore; the habitat for this plant.

Lizzie Peabody: Inside the Herbarium, the scurfpea was dried brown, flattened and stuck to a board. Great for preserving the anatomy of a plant, but terrible for preserving its smell, which had long been replaced by the smell of chemical preservatives. In addition to the scurfpea, Agapakis found 19 other extinct plants that day at the Harvard Herbarium.

Christina Agapakis: Ah, and from there, about 14 of them, we were able to take little tiny tissue samples. So, those are like little bits of leaf or, or a twig or bits of pieces that we were able to take off without damaging the specimen too much.

Lizzie Peabody: So, it didn't even matter what part of the plant you took a snippet from? It could be the petal, the leaf, the root...

Christina Agapakis: That's right! So, the, the whole genome is everywhere (laughs), uh, in every one of the cells. Um, and so we were interested in finding DNA from any piece that we could find.

[MUSIC]

Lizzie Peabody: Armed with tiny slivers of extinct plants, Agapakis returned to her lab. But in the next step, things went from small to much, much smaller.

[MUSIC]

Lizzie Peabody: The secret code that hides a plant's smell resides in its DNA. So Agapakis and her team had to figure out a way to extract DNA from a plant that had been dead for more than a century. The longer an organism is dead, the more its DNA breaks down. They weren't exactly sure how to extract DNA from this old scurfpea cutting, so they outsourced it.

Christina Agapakis: 'Cause you don't want to like, go through this whole process of extraction and destroy the specimen and be like, "oh, I did it wrong." (laughs) "There's no DNA here."

Lizzie Peabody: Fortunately, there are researchers who specialize in extracting DNA from tissue samples that are thousands of years old. So Agapakis' team sent off their scurfpea cuttings and they waited. Pretty soon, they received large chunks of DNA code, typed out letter-by-letter.

Christina Agapakis: I could actually find it for you if you give me a minute.

Lizzie Peabody: Oh, great!

Christina Agapakis: Like the actual sequence and read it.

Lizzie Peabody: (laughs)

Christina Agapakis: Um, I think it's in this one. Let's see. Yep. Here it is. Okay. So yeah, like, they're these really short fragments. Um, and they have like, these codes, so like, it's like "At m-o-two-five, two, five colon, blah, blah, blah." Uh, and then it starts with the actual gene sequence.

[MUSIC]

Christina Agapakis: So, it says: C, A, C, A, A, T, G, C

Lizzie Peabody: If you remember biology class from high school, you'll remember that DNA is made up of four different molecules that spell out the hidden genetic information of all life on Earth. Those molecules are represented by the letters A, C, G, and T. This is what Christina is reading right now.

Christina Agapakis: C, A, T, A, G, T, A, T, A, C, (laughs) G, T, G, A, you know. It keeps going like that for a while.

[MUSIC]

Lizzie Peabody: It tells her lab the exact order in which all of the DNA molecules need to appear. And, this part is truly amazing. Christina's team then prints DNA. It's not naturally-occurring DNA. It's synthetic. But when they put it inside of a living creature, this printed DNA behaves exactly the same way that organic DNA would.

Christina Agapakis: So, then we can transfer that DNA sequence into a yeast's genome. And now that yeast has a little tiny piece of this sort of printed out, like reconstructed version of that ancient sequence of DNA.

[MUSIC]

Lizzie Peabody: So, here's the important thing to remember: these are just random segments of DNA that they've pulled from a tiny piece of an extinct plant. This DNA might tell the plant how to survive a drought. It might tell the plant how to make its petals white or yellow. There are all kinds of plant behaviors dictated by DNA. But, there's a chance that a specific piece of DNA might tell the plant what smells to make. So, as Christina was saying, they put the manufactured bit of DNA into yeast.

Christina Agapakis: Yeah. So, the yeast now has this little DNA in it and it's sort of like doing it's own yeasty thing. It's eating some sugar, it's making alcohol, but it's also making this enzyme that's encoded by that DNA sequence.

[MUSIC]

Lizzie Peabody: This is actually pretty similar to the process of making beer. You feed the yeast, the yeast produces some alcohol. But if Christina's team put the right DNA inside the yeast, it will also create some scent molecules.

Christina Agapakis: And so you have a new smell that's being produced by that yeast that wasn't there before. And, and so small that actually like, you can't smell what it's making with your nose, like it's not enough of the molecules.

Lizzie Peabody: But, they have a machine for that.

Christina Agapakis: Sort of electronic noses in a way.

Lizzie Peabody: These electronic noses analyze this microscopic ooze and tells them which scent molecules are present.

[MUSIC]

Lizzie Peabody: And the plan worked! After years of working on this project, they had a list of the types of smell molecules that the scurfpea's DNA told it to make. Christina says she was kinda surprised they even got this far.

Christina Agapakis: I had almost given up so many times (laughs) that it was such a surprise to be able to be like, "Oh \*bleep\*", it actually worked. (laughs) We did it?"

[MUSIC]

Lizzie Peabody: They didn't have a smell yet, but they were almost there. So, coming up after a quick break, Agapakis turns to a scent evangelist to turn those smell molecules into a full on aroma.

[MUSIC]

Lizzie Peabody: Ok, so we're back. And here's a quick refresher on where we are. The facts: A plant called the Falls of the Ohio Scurfpea went extinct, largely because people flooded, blasted and paved over the only place it grew. Christina Agapakis and her crew decided, "Well, why not try to recreate the scurfpea's smell?" It turned out to be really hard. Over the course of several years, she found a dried sample of the scurfpea, decoded and recreated its DNA, and tricked yeast into producing the smells hidden inside.

[MUSIC]

Lizzie Peabody: But, at this point, all Agapakis has was a list of those smell molecules; ingredients that go into making a smell. Like, if the scurfpea's smell is a cake that you want to bake, this list of molecules is basically your eggs, flour and butter. But in baking, it's really important to know how much of each ingredient you want to put in the bowl as some of us have learned the hard way. The same is true for the scurfpea's smell. So, in order to do that, Agapakis turned to her old friend, Sissel Tolaas. You heard from her at the beginning of our episode. Here's Agapakis recalling the first time they met, years ago through a program that paired up scientists with artists.

Christina Agapakis: And the first day that we got to her lab in Berlin, she's like showing me around the smells and this is again at the time where I feel like, "I don't like smells, I don't know. I'm a little sensitive." (laughs) I didn't want to think about smells too much. And she says, "Okay, smell this," like and it's like, "Oh, okay, it's good." And she's like, "This is cotton candy." I was like, "Okay, great." And she says, "Smell this. It is dog \*bleep\*." (Laughs) And she's like, "Smell this, it is David Beckham's feet."

[LAUGHTER]

Christina Agapakis: You kinda go through this like whirlwind of smells like all over the world.

Lizzie Peabody: So, when Sissel Tolaas and Agapakis started talking about the extinct plant smell project, Tolaas was always a critical piece of the puzzle. It was her job to figure out how to take a list of molecules and make a smell.

Sissel Tolass: First of all, I have a chemistry lab up here consisting of up to 6,000 smell molecules. And then, I have access to uh, most molecules that I use for smell and taste creations. Yeah?

Lizzie Peabody: So, Sissel heads to her lab and gets sniffing.

Sissel Tolass: First I smell all individual molecules and make a list of what is most dominant, what are strongest. And then I build up a kind of structure, like you build a house, you make a skeleton. And then you fill in the empty spaces

Lizzie Peabody: This is all part of Sissel's art: she has an innate feel for the component parts of a smell. But it's important to note, the list that Agapakis sent wasn't comprehensive. In Sissel's version of the scurfpea scent, there would be more of those empty spaces than in the plant's actual smell.

Sissel Tolass: In the end, you know, we are just speculating here because they're much more molecule probably in their original plant than we were able to detect, but I had a few molecules and I have to imagine the rest and I didn't want to fake, I literally worked with what was detected. I didn't add any extra molecules. Yeah?

Lizzie Peabody: So, what's the hardest part about recreating a smell from scratch like this?

Sissel Tolass: The hardest part is when to stop, you know? Because it can go all kinds of directions. But...

Lizzie Peabody: Right.

Sissel Tolass: ...because there are a couple of core molecules that are always dominant, that core molecule is always present, yeah?

Lizzie Peabody: Yeah.

Sissel Tolass: ...which is also good because working from scratch is very complicated. So, in this case, I didn't have a source to record from, you know, where I could literally replicate the findings.

[MUSIC]

Lizzie Peabody: So, once Sissel had a dozen different profiles of the smell, using only molecules found in the scurfpea's DNA analysis, she shipped them across the Atlantic to Agapakis' lab in Boston.

Christina Agapakis: This was like a few months later, she sent a box with like 12 tiny little vials and those were different sketches.

[MUSIC]



Lizzie Peabody: Four years after this project started, Christina Agapakis and her team finally got to take their first whiff of the Falls of the Ohio scurfpea. For the moment of truth, Agapakis assembled her team, they cracked open the vials, and together, they sniffed the past.

[MUSIC]

Christina Agapakis: It really did feel like magic. Um, especially like as a scientist, as someone who's like used to being in the lab, like in being so, um, so far from something like experiential, like to always be experiencing something through those lenses of the data, to be able to get it so viscerally. Uh, it was really special.

[MUSIC]

Lizzie Peabody: You're probably wondering, "Well, what did it smell like?" And, we all get to learn that in just a second. But first, they knew it wasn't enough to just recreate this scent. They wanted to bring this smell to the public in a meaningful way. So, they called in another one of Agapakis' super-friends.

Dr. Alexandra Ginsberg: My name is Dr Alexandra Daisy Ginsberg and I'm an artist.

Lizzie Peabody: But she's not your typical paint-on-a-canvas type of artist. Ginsberg has her doctorate in design and often works on projects involving synthetic biology and other complex science. She first collaborated with Agapakis and Tolaas in 2013. But for this project, Ginsberg's job was to design a museum experience that would translate the smell and the ideas of the loss of nature behind it for public consumption.

Dr. Alexandra Ginsberg: I had to learn a lot about even the technology involved.

Lizzie Peabody: Hmmm.

Dr. Alexandra Ginsberg: ...and in terms of how do we experience smell and diffuse it within a space. But the challenge was also how do we convey, so for me on a more meta level, how do we convey the emotional experience of once again experiencing something that has disappeared.

Lizzie Peabody: Part of it is a practical problem. How do you display a smell? Ginsburg found some pumps that would diffuse different versions of the scurfpea scent; a few of the different profiles that Tolaas made at random intervals.

Dr. Alexandra Ginsberg: So, the smell mixes around your head and there is a, a contingency to your experience. There's no exact smell and it's up to you as a visitor to sort of define it for yourself.

Lizzie Peabody: And so, to define it for myself, I took a train up to New York City and visited the Cooper Hewitt, the Smithsonian's design museum. This is where we met Andrea Lipps, curator of this Cooper Hewitt exhibition, that looks at how designers interact with nature.

Andrea Lipps: So, that's why you see everything in here from smell design to landscape architecture to product design, to communication design. I mean, it really is such a wide swath of, of what's happening.

Lizzie Peabody: So, can you take us to the smells?

Andrea Lipps: Yes! I would love to.

[FOOTSTEPS]

Andrea Lipps: So, what I always do is I invite visitors to step under the hood.

Lizzie Peabody: Picture a sort of wide square lampshade that's set about five and a half feet above the ground. I had to stoop just a little to get my head inside. And once I did, I heard a very faint whirring above my head. This sound is the smell diffusers and an aroma wafted into the hood.

Lizzie Peabody: Oh my gosh.

Andrea Lipps: Do you smell it?

Lizzie Peabody: Yes!

Andrea Lipps: Yeah.

Lizzie Peabody: Whoa!

Andrea Lipps: So, there's a diffusion of scent molecules that are released when we stand under the hood.

Lizzie Peabody: Wow. It's quite fragrant.

Andrea Lipps: Hmm, mmm. It really is. Yeah. It's really nice.

Lizzie Peabody: It smells like something I feel like I almost recognize.

Andrea Lipps: Hmm, mmm. Yeah. There's like a sweetness. Almost a tang to it.

Lizzie Peabody: Yeah. There's something a little citrusy.

Andrea Lipps: Yeah, right? Definitely.

Lizzie Peabody: But something decidedly floral...

Andrea Lipps: Yeah.

Lizzie Peabody: ...as well. Almost like rose, lemon...

Andrea Lipps: Yeah.

Lizzie Peabody: ...and rose.

Andrea Lipps: Isn't it interesting to try to describe smell? (Laughs)

Lizzie Peabody: Yes. It's very hard.

Andrea Lipps: Very difficult. I mean, we, the only way we can ever describe smell is in relation to something that already exists.

Lizzie Peabody: Right!

Andrea Lipps: They're just, there aren't unique words for it. Like the sweetness, the rose, the lemon. Yeah.

Lizzie Peabody: And every whiff. I mean, every time I breathe in, I feel like I get something slightly different.

Andrea Lipps: Hmm, mmm.

Lizzie Peabody: And it gets a very multidimensional smell.

Andrea Lipps: Yeah.

Lizzie Peabody: It's not just, you know, a wall of perfume or something.

Andrea Lipps: Yeah, exactly.

Lizzie Peabody: Under the hood, there is a single limestone boulder on the ground. Artist, Alexandra Daisy Ginsburg, says she put it there, to remind visitors that this is our destiny, these disconnected bits of lost environment, if we don't fix how we relate to nature. So, after I visited the exhibition, I wanted to ask her about that decision. And it seems to me that at the end of the day, the flowers' smell is unknowable, because sitting on an island in the Ohio river, that would be a very rich experience because you would smell the grass and the river and the wet rocky

soil, and who knows what else. And it would be very different from standing underneath sort of a lampshade in a museum gallery catching a note or two of its scent.

Dr. Alexandra Ginsberg: Exactly. And, and that's part of, for me, my interest in this project is, you know, you could recreate the smell of a flower, but it's not really the smell of the flower. It's always going to be an approximation. And that's also what we're trying to do in the installation is you have this impoverished experience of nature. You know, it's just a couple of rocks and the smell of a flower and you know, is that the future that we want? So, while the promise of the technology is so exciting that you could do something as immense as learn how a flower might've smelled from a pressed specimen that's centuries old, at the same time, the experience that you get from it is deeply, you know, deeply sad to me. You could go outside and smell flowers and to go through all of this to, to experience something, you know, something that we've already destroyed through a lack of care for the environment is, is really, I want people to leave with the sense of loss and using biotechnology to synthesize loss is for me a very fascinating thing to explore.

[MUSIC]

Lizzie Peabody: This project offers a look into our past. It offers something apparently simple: the scent of a wildflower; but it's so complex that these brilliant minds worked on it for years, and can only offer a faint glimpse into its real smell. It seems like it would be a lot easier to just keep these organisms alive in the first place. But looking at it another way, there's hope. If this young science can find and recreate the smell of an extinct plant, even if it takes a little bit of imagination when you smell it, think what's next. There are an infinite number of extinct plants, animals and even microbes with DNA that was created by evolution. That DNA holds secrets. In some not so distant future, those secrets might give us new flavors, new ways to make blood clot, new ways to kill bacteria. And in the meantime, as Sissel would say, "There are no bad smells." So, smell your world, while you still can.

[MUSIC]

Lizzie Peabody: You have been listening to Sidedoor, a podcast from the Smithsonian with support from PRX.

[MUSIC]

Lizzie Peabody: If you're in New York City and you want to smell the scurfpea in person, which I recommend, check it out at the Smithsonian's Cooper Hewitt Design Museum. It's on display until January 12, 2020. And if you can't make it, well the next best thing is looking at a picture of me smelling it, which I will include in the Sidedoor newsletter. Subscribe at [si.edu/Sidedoor](http://si.edu/Sidedoor).

[MUSIC]

Lizzie Peabody: We want to extend a special thanks to Julian Campbell, Michael Homoya and Margaret Carreiro. We also want to shout out Rowan Jacobsen's reporting. He wrote a version of this story in the Scientific American.

[MUSIC]

Lizzie Peabody: And, if you like the show, leave us a review in Apple Podcasts. A good review for a podcast you enjoy, is like a nice tip for a good waiter. It's the polite thing to do. Sidedoor is made possible with help from people like you. Your generous support helps make all the amazing work you hear about at the Smithsonian possible.

Lizzie Peabody: Our podcast team is Justin O'Neill, Jason Orfanon, Michelle Harven, Caitlin Shaffer, Jess Sadeq, Lara Koch, and Sharon Bryant. Episode artwork is by Greg Fisk. Extra support comes from John Barth and Genevieve Sponsler at PRX. Our show is mixed by Tarek Fouda. Our theme song and other episode music are by Breakmaster Cylinder.

[MUSIC]

Lizzie Peabody: If you want to sponsor our show, please email [sponsorship@prx.org](mailto:sponsorship@prx.org). I'm your host, Lizzie Scurf-Peabody. Thanks for listening.

[MUSIC]

Christina Agapakis: My x key doesn't work, so when I search for extinct, it's really hard.  
(Laughs)

Lizzie Peabody: Oh no! Of all the keys not to work! (Laughs)

Christina Agapakis: Of all the keys! (Laughs)