The Taproot podcast

Season 3, Episode 4

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Guest: Simon Gilroy

Transcribed by Joe Stormer

[Instrumental theme music]

Liz Haswell: Hello, Taprooters! I'm Liz Haswell, and today we have a truly amazing interview for you – one that will definitely activate your glutamate receptors.

Ivan Baxter: And I'm Ivan Baxter. Today's guest is Simon Gilroy from the University of Wisconsin at Madison. We'll discuss one of his recent (and certainly most celebrated) papers, talk about plants "neurobiology", plants in space, and bust the myth that everyone in plant science is motivated by a desire to feed the world.

Liz: And as a special bonus, Simon laughs a lot and it's a very special laugh. So with that, let's get to the episode.

[Instrumental theme music]

Liz: Welcome, everybody. Today's guest is (and I wish I had a drum set so could go [simulated drum noise]), Simon Gilroy! As you'll hear, Simon is originally from the U.K. and he did his PhD in plant biochemistry with the famous Anthony Trewavas at Edinburgh in 1987. After a couple post-doc fellowships, he joined the faculty at Penn State and, in 2007, he moved to the University of Wisconsin Madison, where he has a very active and apparently very gregarious lab based on his Facebook page. He teaches a lot, he organized to fantastic Mid-West plant cell biology meeting, and is very active in the plant cell community. Simon has been at the leading edge of research in my field - plant mechanobiology - even starting in his PhD work. He's been trying to understand how calcium signaling in plants works, and how it helps transduce important signals like gravity, wounding, and mechanical force. So welcome to The Taproot, Simon.

Simon Gilroy: Thank you!

Ivan: It's fantastic to have you here, Simon. Today's paper is Toyota et al in Science 2018 and the title is "Glutamate triggers long-distance calcium-based plant defense signaling". It really got just tremendous amounts of press. In prepping for this, I listened to Simon on Science Friday. He got written up in the New York Times. You may have heard of this paper before, even if you're not a hardcore mechanobiology, calcium-transport, or signaling person So Simon, do you want to give us a quick summary of this paper?

Simon: Yeah! So we've been interested in how plants communicate within the plant body, and so that's the big theme of what the paper is addressing. There were two bits to it. One bit we were really hoping that we would see (and kind of thought that it would be there) is if you wound a plant, how does it send signals throughout the plant. So we used some imaging technology to be able to see that wave of that information as a wave of calcium move through the plant. So that was pretty cool, that was pretty awesome. There was an unexpected bit of it as well, which is (in trying to work out the mechanism behind that) we sort of revealed a role for the amino acid glutamate as a signal for that long-distance information system - which is SUPER unexpected.

Ivan: If you have not seen a Simon Gilroy talk, it is always a pleasure because he always has the coolest movies of signally in plants.

Liz: Simon came and gave a seminar here. He was our student-invited speaker, I think last year. And the ooo-ing and ahh-ing when you damaged the plant leaf and there's this big calcium signal and I think that partly what's so compelling about it is you can see it at the whole-plant scale, right? So everybody's seen a calcium wave somewhere (in a pollen tube or some kind of a nerve cell or something), but seeing that on the scale of a whole plant leaf was just really compelling. Did you have to develop some technology to make that possible? Or why weren't we seeing this before?

Simon: It's a combination of a lot of technologies and ideas coming together. So we didn't develop the imaging approach; we just sort of used it. There's a bunch of labs that are just doing that unbelievably awesome protein engineering stuff where they're taking green florescent protein and then engineering the structure of the peptide in order to be able to change its florescence in response to a whole bunch of different parameters. So fortunately, in the medical world calcium is a big deal. So there's lots of labs that are developing these awesome tools for imaging calcium and they've just sort of of come of age. We've had very good tools for a good few years to make these kind of measurements but they've not been the kind that you can use with the sort of low-magnification that would let you see the whole plant. So we've been able to look at cells and get lots of cellular resolution. But this family of new imagining tools just became available (I would guess five or six years ago), and that just opened up the floodgates of being able to make these kind of measurements.

Liz: SO just being able to use a dissecting scope that you've fitted with confocal imaging, or I guess it's probably not even confocal.

Simon: No, it's just a regular epifluorescence microscope. The absolute awesome thing now is: up until fairly recently, I think to be able to make the measurements (these kind of calcium imaging measurements and of the in vivo dynamics of what's going on) was very technically demanding and you had to have some really high-end equipment and you had to know really what you were doing. And now if you've got a florescent microscope and you have plants expressing the GFP, if you can image green florescent protein with whatever technology you have, you can make these kinds of measurements.

Ivan: Is this the kind of thing you imagined you always wanted to do, this kind of imagining? Or is it the kind of thing that you never would have guessed was possible when you started in the late nineties?

Simon: The answer is *yes* to both of those. When I was doing my PhD with Tony

Trewavas, this is the kind of things that we knew plants had to be doing. You know like in your heart of heart (if you were a plant biologist who works on signaling) that plants are super dynamic and this kind of stuff has got to be in there somewhere - but the technology just didn't exist. And over the course of - you know - two decades, technology moves on and finally we've caught up with those ideas. So once we've got those movies of wound waves moving throughout the plant, first person I sent them to was Tony Trewavas and I just said, "Here you go." I emailed him (but without the movie) and I said, "I think I've got something that you're going to be super interested in," and he emails me back and goes, "Have you imaged the calcium waves now?" [Laughs] So then I sent him the movies. It was absolutely fantastic.

Liz: I want to know what it felt like to be such a science celebrity when that paper came out.

Simon: Oh, that was just so weird. [Laughs]

Liz: [Laughing] Cuz I've known you for a while, Simon, and you always felt like sort of somebody I could relate to and a scientist who is exciting and is doing stuff that I understood. I felt like your peer, but now you're like a science celebrity. It's so cool.

Simon: [Laugh loudly] Oh, I am still the humble person that I was before. It's very weird, very weird. Cuz with that, the work that's in that Science paper is literally five years of research, and the post-doc that is now a professor in Saitama University (Masatsuga Toyota) just accumulated the stuff over a really long period of time and we got closer each year to getting the story, but there was always this feeling that we hadn't quite got to describe what was going on. So we presented that story in its various forms over the course of the years in a lot of different conferences and different talks and things like that. And it was clear that the research community liked it – the movies of varying engaging and that kind of stuff. But it was very unexpected how the whole just popular science thing took off and for that I totally have to give a shout out to Eric Hamilton.

Liz: Really?! My graduate student, Eric Hamilton? Fantastic!

Simon: Yeah! Our communications guy. This is the way it worked. We had the story, got it through Science and knew it was going to be published. So I contact Eric and Eric writes like a press release. And that goes to a site that only journalists have access to before the paper is published, so there is an embargo on releasing data and the paper and all that kind of stuff. And that started the ball rolling and then it got bigger and bigger, and on the day before the paper was released I was on the phone doing interviews constantly and it was very, very weird. I mean it was cool. Don't get me wrong, it was absolutely awesome; it was just very unexpected how much it took off.

Liz: So I have a question for you about glutamate, which is of course a neurotransmitter as well as an amino acid. Where do you think plants are storing this, right? I mean there has to be a lot of it if it's being held somewhere in order to serve as signaling molecules for the glutamate receptors.

Simon: Yeah, this is kind of where we're at, I think. We have pretty good evidence the glutamate is sitting inside plant cells, and in response to wounding it goes into the cell wall and that is the trigger – the molecular pattern that tells the plant that the cell is damaged. Internal concentrations (just like the ambient concentrations of glutamate) are probably in the many millimolar range – that's the measurements that have been made.

Liz: In the cytoplasm? Or in the vacuole?

Simon: In the cytoplasm, yeah, cuz it's kind of tricky to know how do you make those measurements? How do you get at the ambient glutamate concentration in the cytosol? But so our model is that glutamate kind of "leaks" from the damaged cell, whatever "leaks" means. I like the kind of simple one which is that at the wound site, you've just broken open a sort of glutamate and the glutamate leaks out of the damaged cells and then triggers the intact cells around to just freak out. That's literally the model we're trying to test at the moment, cuz we don't know if that's true.

Liz: Is that how it happens in animal cells?

Simon: No, in animals cells it's a very much more regulated. So if you think of a synapse (two nerve cells that are gonna talk to each other) - one nerve cell has vesicles packed with glutamate and, in a very regulated and controlled way, dumps that glutamate into the synaptic cleft and that triggers the next cell. That could be what's going on inside plants.

Liz: Yeah, there could be exocytosis in response to, I don't know, membrane tension or something.

Simon: Yeah. Then it becomes very interesting. Cuz the unexpected thing is that then we have glutamate as sort of an extra-cellular signal that looks to be triggering waves of calcium through the plant; that's kind of what we think is going on. And that kind of looks like how the animal nervous system looks. And some of the molecular players might be the same so the glutamate receptors in plants look like the glutamate receptors in animals, so it's I think it's one of those awesome pieces of biology where apparently biology worked out how to do something and really doesn't have to improve on it. It's got the machinery there, and it's used by all sort of different cells – lots of different animals, lots of different plants.

Liz: So you think the society for plant neurobiology is going to see a resurgence now?

Simon: [Giggles] I have my standard disclaimer – plants do not have nerves.

Liz: But they have nerve-like systems, what would you say?

Simon: They might have a nerve-like system, but a nerve is a very clear anatomical thing in an animal and you can totally tell what a nerve is. So plants don't have that, but I think all plant biologists - we all know that plants sense in their environment and have to integrate that across the plant body; that's intrinsic to just being a plant. That's what makes them so awesome. So they have to have a system that does the same *kind* of this as a mammalian nervous system, but it's not the mammalian nervous system. But again that's the awesome thing about being a plant – you're different but you have the same challenges in the environment.

Ivan: So the answer is, “No, they don't have a neurosystem.”

Liz: But they have an analogous system, right?

Simon: No, they do not.

Ivan: They don't think.

[Laughter]

Simon: They do not have a nervous system. They do not have a brain, if you define a brain as the big gobby thing on top of our heads.

Ivan: [Laughs]

Simon: So this is the kind of thing that drives a lot of the research that goes on in the lab. You kind of know how animals work because we're animals. Medical science is awesome and we have lots of insight into how we do things, and it's very obvious to us because that's how we operate. And then you look outside and you see a plant growing out in the soil - and the challenges it does and the things it has to do are super similar to what animals have to do. It's going to do some of them in a different way. It doesn't have muscles and all that stuff. But it still has to take in information and process it. But it doesn't have a brain. It doesn't have the machinery that we have. But it's doing analogous things and, “How on Earth do you do that?” That's an awesome question to try to answer.

Liz: And the other thing is the time scale's different.

Simon: Except I think the better we get at doing the measurements, the more we're realizing, “Okay, the plants play out their growth and development as their big way of dealing with the world.” Which is inherently kind of a slow process because you can't screw it up. Once you've grown in a particular way, you can't pull that growth back. But as we get better at making the measurements, the timeframe of all of the regulatory stuff and all of the information processing, I think we really are at just the millisecond timeframe that you think that animals work at as well.

Ivan: I would say that any parent of a young child would say that growth and development can be a very slow process. [Laughter] So, I guess if this was a different kind of podcast (one that always takes the titles from some funny thing that someone says), the title of this one would be “The spongy bit on top”.

Simon: The GOBBY bit. Oh, it would be much better if it was the spongy bit. “The spongy bit on top” - that sounds more science-y.

Ivan: Simon, this got a tremendous amount of interest. You got Science Friday which (I'm not going to say I'm *jealous*) but I'm jealous.

Liz: I'm jealous.

Ivan: And the New York Times. But this is a very basic science question. Why do you think this is able to get such attention? Do you think it's because you're really good at PR? Is it that it's just the pretty pictures? What's the key here?

Simon: I've tried to think of the answer to that question before, because it was remarkable. We knew that the science world thought it was cool, but it's a science-y question. It sort of caught the public imagination, but partly because “seeing is believing”; it's a very accessible thing to be able to see the biology play out in front of you. That makes it more accessible, but I think that it's just that there really is a tremendous interest in everyone about how the world works, and this is just the surprising and sort of interesting, cool insight into how plants operate that people hadn't really thought about before. And then it's laid out in front of you so, yeah, I think it sort of hit the nerve of, “Wow, I never would have thought of that but that is kind of cool.”

Ivan: So it's interesting you say that everyone has this kind of innate curiosity about how the world works, because we have I think in our culture a real desire to link what we're doing to outcomes. I notice even in your Science Friday interview when you talked about this, you took it even the next step of like, “Well, if we can understand this we can teach plants to respond to the environment better.” You said that. There is this drive, you know, not to say, “We do this because it's effing cool.” We can't just say, “We just want to know this.”

Liz: Yeah I did one of those Alan Alda communications workshops up at the medical school a few years ago where we were practicing our elevator pitch, and all of the people in that room would not let me say, “This is interesting because we don't know how plants do this.” They're like, “Why? Why would I care?” And I finally said, “You don't make somebody who's involved in space research or deep sea diving” – like that's obviously interesting. Why can't PLANTS be just obviously interesting and curious. It's really a weird dynamic. So it sounds like you also, Simon, felt obligated to link this to human outcomes – outcomes that benefit human health.

Simon: So I don't think anyone in my lab does the research because we think we're going to feed the world. We're driven by the curiosity of how things work. There's two kind of really big things for research. There's directed research where the drive to do the research is a question with a very defined outcome and the goal is to move towards a product. There is awesome and there's a balance between that and the role of research in extending knowledge. And I think it's entirely appropriate for the general public to want to have some way to linking into the research. For some people it's the product that makes it obvious of why the research has got to be done. But still I think a lot of people find stuff interesting. My only insight about universities is: you can go to anyone who is a professor at a university, and if they can tell you why what they work on is interesting, you can totally find it interesting because they can get across the enthusiasm and the questions and why they think it's interesting. I do think it turns out that stuff is just interesting. But yeah, the there is a flip side of it that there's some point where there might be a product. But if your research is designed to get to the product, that's a very different thing from “I wonder how this works”. And sometimes it's that the venue wants a product.

Liz: Yeah. Should taxpayers want everything we're doing on their dime to be leading to a product or should they be paying for us to scratch our “What does calcium do in plants" itch?

Simon: [Laughs] You know, if we were all omnipotent and we knew everything, there'd be no point in us doing research. But if you knew the outcome of everything, then maybe that would, "This should be directed because we have this output that we need", but we don't and you have no idea. As that big body of knowledge gets bigger and bigger about how the world works, that is the thing that supports the next round of products. And I don't know what the important questions to get to the next big thing that is gonna double food production is, but I am pretty certain that the accumulated knowledge that we're building now, at some point, something's gonna come together to do all that stuff. But if you don't do all of the big "I wonder how it works" stuff now, the next round of stuff is simply not going to happen.

Ivan: I think there's clearly a push and pull there, right, because we absolutely need to be just figuring out stuff. It's not that applied research doesn't lack imagination, but it has to be confined in the way that we understand things today; and we understand so little about our world in reality. So we have to be going out into the world and trying to understand things. And maybe we just haven't made that case clear enough cuz that's certainly something that we all agree on. It's really a question of "How do we frame that as important?" and "Can we make the case that we have to understand this stuff just to understand it?"

Liz: Yeah, I think that's right. Saying that basic research is an important fundamental for applied research is one thing. But that's just basically saying that somewhere another we're all working toward application. But is there space to say, "It's okay to do research on taxpayer money that's just to understand the world," like studying evolution or studying (I don't know) just something that there's no application. Is it okay to study that?

Simon: So I have two kind of thought on that. One is that no one knows how future application will work, so every piece of knowledge is important. And if you think that knowledge is a product – which I kind of do – then basic research that is answering questions about how the world works is producing an INCREDIBLY important product which is a part of improving the human condition. Knowledge is a good thing; the more we understand, the better the world is as far as human beings are concerned and the knowledge itself is product.

Liz: So I agree with that wholeheartedly. I feel like your research is such a good example about how understanding plants helps us as humans understand our place in the world, right?

Simon: Mmhmm.

Liz: Cuz we can see the ways we're like plants; we can see the ways in which we're different from plants; we can see the ways in which they've solved the same problems that we have (which is how does my brain know what my leg is doing). The plant needs to do that same long-distance communication job; it does it in a similar yet different way. I feel like that informs us as humans – like the human condition is to understand the natural world. That's part of our jobs as humans. And I may have written that in a broader impact statement one time, but then I learned not to do that.

[Laughter]

Ivan: Did that not get funded?

Liz: It did get funded but i'm pretty sure there was something in a reviewer that said, "Don't do that. We need to hear broader impacts," or "That's too lofty, too philosophical," or something; I can't remember.

Ivan: That's a question for you, Simon. Have you ever made that case in a grant proposal? You've always been quite successful funding your lab, I would say. Or reasonably successful?

Simon: [Stammering] The . . . uhh . . . no? [Laughs] I think about every grant proposal - you know, if you think of the classic National Science Foundation broader impact statement, the formula for those is pretty much every one of those has of broader impacts is description of how the science will move our understanding forward. And then it has all of the others stuff that is sort of expected for how you're going to broaden how your research impacts the world on how just answering the science questions. So I think everyone sort of has that bit of "I'm gonna discover this important stuff and it will move the field forward," but I don't think knowledge-for-knowledge-sake will necessarily be the best broader impacts for an NSF grant.

Ivan: Let me just follow up on that question about your funding. To a certain extent you have been funded by the NSF and NASA, most of the time that I've known you. The NASA stuff is [tentatively] more applied, although I think that a lot of what you are doing for them is sort of asking questions about plants in gravity. But they want [grand tone of voice] PLANTS IN SPAAAAAACE. Have you ever thought of "How could I do what I'm interested in and make it in a more applied sense," and gone after that kind of funding?

Simon: It's not the kind of science that I think I'm good at. I think that's just so hard, to think about how basically I want to improve a plant. That is a hard thing to do. Plants are pretty awesome. Evolution has equipped them with a pretty amazing set of tools to deal with the world and the kind of stuff that I'm interested in are much more the questions of "How does it work?" I haven't really gone down the road of applied crop improvement or something like that.

Liz: But you are sending plants into space.

Simon: Yes?

Liz: And what's the purpose of that?

Simon: [Laughs] There are two components of that. And NASA guys [sic] totally know that there are two elements of what they're funding. There's the very applied part of it, which is if you're gonna have astronauts that are gonna live for a very long time away from the Earth, somehow you've got to feed them and keep them alive; and the question is whether plants can do that role. So there is absolutely an applied component to it. But if you put a NASA grant proposal in, most of the requests for proposals absolutely require you to be testing a biological hypothesis. So there's a lot of technology and a lot of directed research from NASA which is “Build me a better greenhouse in space” - that kind of work. But then there's also a huge proportion of what is funded is, “Use space flight as a laboratory to understand how biology interacts with the things that you can change but you can only do it by going to space.” So what happens when you get rid of gravity? What happens when you increase the radiation dosage? What happens when weird physical phenomenal get screwed up because of the place where you are? And so most of the research that we do in the NASA realm is not improving plants to grow them in space; it's to understand how biology reacts to this weird environment. And a lot of it is telling us how plants work. It's a laboratory that you can't – the experiments that you can do on the space station, most of them you can't do anywhere else. This is very basic biology set of questions, which are the NASA questions.

Ivan: And that's just where you've always felt comfortable running you career – running your lab and directing your lab is at the basic level.

Simon: [Laughs then pauses] *Comfortable* might not be the right word. [Laughter] It's the place where the questions just naturally come. It wouldn't be a direct natural, obvious thing for all of the people - cuz the lab is a team. So it's not just me and it's the post-docs and it's the scientists and it's the grad students and undergrads. The questions that naturally form for us are the basic questions of, “How does this work?” Somehow if it had an impact on improving crops, that would be awesome but it's not why questions come to our mind.

Ivan: So Simon, one of the things that we really try to do on this podcast is give advice to young scientists, emerging scientists. If someone is coming up and they're trying to figure out their niche, how should they sort of evaluate this idea of whether they should try and think of things in an applied direction or go for very specific “I wanna be answering this question” and evaluating whether that's a good career choice.

Simon: If it gets to that point where you are going, “What's my next step?”, at that point you kind of know what floats your boat. You know are there a bunch of biological questions that you just find interesting or is "Increasing yield by 20%" - that is a goal where I could see myself making an impact. If it's not fun and it's not interesting but you feel you have to do it, you're probably not going to be good at it because you can't just invest that time and the effort and the constant in-the-back-of-your-mind swirling around ideas that is what science is all about. So I think my only advice is just find out what floats your boat and run with it.

Ivan: And you can get paid for doing it.

Simon: Well, it would be good to be being paid for it, I'd say.

Liz: Yeah, that was where I was gonna go. Like, okay, if you are a person for whom basic plant science floats your boat, I really do see this message, "The reason we're all here doing plant science is to feed the world." That's been said to me directly. I've seen ASPB luminaries state this in their letters, "No matter what we're studying, we're all here to feed the world." How can basic biologists make our point without being jerks? [Raucous laughter] Actually we're NOT all here to do that. It's not that I don't care about hungry people, but I don't really care about doing that in my own lab. I just care about figuring out why this one kind of protein works. Right? How do we do that?

Simon: [Sigh] That is tough, and maybe it circles back to the beginning. If audience needs a product, then basic research is gonna support future products. But you know in a university setting, we are incredibly lucky. If you have a university faculty position or you work somehow in a university, kind of our job is increase the base of knowledge. So I don't think I have a really easy answer for that.

Ivan: Have you experienced those same kind of challenges to you?

Simon: You mean has someone gone, "You know, our role as faculty in the botany department is to improve agriculture" - that kind of undercurrent?

Ivan: Probably it happens more when you're at the junior status and people are challenging you so this may even go back to Penn State when you were there.

Simon: No. I don't think I've had that kind of push. Penn State is a biology department with an ENORMOUS breadth of research. It's a fantastic place cuz everyone appreciates everyone else's stuff, but there are people who've worked on infectious diseases and then there's people working on plant cell walls. So I think that environment sort of pushes you to have to think outside of the immediate product because you've got to somehow get into that hugely broad area of research which a biology department encompasses. Same deal with the biology department at Madison, where everyone from molecular evolution to "How does the endoplasmic reticulum function;" I don't think there's been an obvious, "Why aren't you breeding better plants?"

Ivan: [Laughs]

Simon: But that might just be because it's not what I'm gonna do, and maybe people have realized that that's not what I'm going to do.

Liz: Okay, so speaking of what you ARE going to do, you are on sabbatical right now at NASA.

Simon: Yeah, I am on sabbatical at Kennedy Space Center right now, and that's to actually ask a bunch of questions totally way out there about circadian rhythms, gravity (that's the research I'm doing down here). And when I'm here we get access to play with some of the hardware to begin to work out how to do the next generation of space flight experiments. But again, they're all driven by really basic questions about things like how does oxygen sensing impact on how plants work; and that turns out that, when you go into space, how gasses move gets screwed up and there's some really interesting questions there. So hopefully we won't run out of questions.

Liz: [Laughing] I don't think there's anything to worry about.

Ivan: I mean I think this is true on both the applied and the basic side is that you have to have things that make you excited (that you want to get up and do) that at least some other people thing are worthwhile. So this idea of trying to find that, that linkage. So when you are advising students now, Simon, undergrad or graduate students, what kind of advice do you have for helping them shape that question? Because it's great to say, "Do what gets you excited," but I think that it's hard enough for people that are already experienced to know. And if you get people who are like, "I have this really great question," and you're like, "That's actually badly framed and I know it's exciting to you but you're not gonna - ". I get a lot of undergrads especially coming to talk about summer projects that they're very excited about a question that is REALLY not well grounded in reality.

Simon: This is the hard bit of the science career. It's a huge pyramid, irrespective of whatever area you think you're going to end up in. When undergraduates first come in and do that thing of, "I'm interested in doing research." And if you work in the space scientists, the funnel is enormous because everyone gets super excited because, "Ohhh, we're going to put plants in space." You have to do that very basic thing. "So the things that you like to do – do you like to clone genes or do you like to wander around in the field will a pair of Wellington boots on?" You know, this is some really big scale things that can sort of put you in the framework of thinking about what you really like to do. I don't know that I have really good advice.

Ivan: Anyone that has seen Simon's talk knows that he claims that all he does is drink coffee.

Simon: Ummmm, well I am NOW because I'm on sabbatical. [Laughs]

Liz: You're on sabbatical, yes.

[Laughter]

Simon: All I do is I drink coffee and I get out of the way of the people in the lab that are actually going to make progress - which is everyone else. One of the good thing about going on sabbatical is you can actually sit in a sterile hood and you can plant the *Arabidopsis* seeds, get back to the basics.

Liz: [Laughs] That some basics, huh? Putting the *Arabidopsis* seeds onto the petri plates?

Simon: Yeah!

Ivan: That's what I did in grad school. [Laughter]

Simon: We always, you know, for the NASA guys [sic], cuz everything we do at NASA, it's all *Arabidopsis* research. It's all really basic stuff; we do transcriptomics and stuff like that. It's not growing lettuce and the things like the target crops for feeding the astronauts. And we just go, "If all we need to do is get the astronauts to get a taste for *Arabidopsis*, then suddenly we would solve all these problems!"

Liz: So didn't a Chinese groups just like germinate a rice seed -

Simon: Cotton.

Liz: Oh, cotton – on the Moon?

Simon: On the dark side of the Moon.

Liz: And then it died.

Simon: Yes.

Ivan: Well, I think that's a good place to end, on the dark side - killing off plants on the dark side. Dark, sad, dead cotton germinated seeds.

Simon: [Laughs] I'll have you know that was a great stride for human – one small step for a cotton plant, one giant leap for cotton kind.

[Laughter]

Ivan: Well, that was a great conversation, Simon. We really appreciate you coming on and sharing your insights with us. If people want to give you feedback, how can they get in touch?

Simon: So either through my faculty email account. Or if you go to the Gilroy Lab Facebook page, just contact us through there.

Ivan: Alright. And Liz, how can people find you?

Liz: You can find me at @EHaswell on Twitter.

Ivan: And you can find me at @BaxterTwi, or you can find the podcast at @TaprootPodcast. And with that, thank you very much, Simon.

Liz: Simon, we're so glad to contribute to your towering list of ways in which you've gotten your story out.

Simon: Thank you!

[Instrumental theme music]

Ivan: The Taproot is brought to you by the American Society of Plants Biologist and the Plantae website. It is cohosted by Ivan Baxter and Liz Haswell and produced by Mary Williams and Melanie Binder. We get editing help by ASPB Convirons scholar Juniper Kiss, and social media and blog post writing help by ASPB intern Katie Rogers. We are very excited to have Joe Stormer help us with the transcripts for Season 3. If you like this episode, tell your friends and colleagues, and be sure to subscribe on iTunes or your podcast player of choice. Thanks for listening, and we'll bring you another story behind the science next week.

[Instrumental theme music]